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7. Abstract

8. ~~PURPOSE AND USE OF DOCUMENT - This document was prepared for use within the U.S. Department of Energy and its contractors. It is to be used only to perform, direct, or integrate work under U.S. Department of Energy contracts. This document is not approved for public release until reviewed.~~

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1.0 INTRODUCTION

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1991) or Tri-Party Agreement outlines a plan and schedule to clean up the Hanford Site by the year 2018. Cleanup of waste sites in compliance with the Tri-Party Agreement and state and federal environmental regulations is one of the primary responsibilities of the Hanford Site Environmental Restoration (ER) Program.

The Tri-Party Agreement Action Plan includes milestones and major tasks, and outlines the Comprehensive Environmental Response Compensation Liability Act (CERCLA) remedial investigation/feasibility studies (RI/FS) process to evaluate sites and determine appropriate remediation. However, the Tri-Party Agreement does not identify specific technologies that may be used to clean up the Hanford Site, nor does it mandate a particular approach to establishing baseline technologies or streamlining engineering and/or technology development activities.

The intent of this document is to provide a starting point for the Hanford ER program from which assumptions can be made and technical support planning for waste site remediation can be realized. Baseline technologies provide a basis to evaluate and prioritize technology development and application needs for the Hanford ER Program, this baseline technology plan will be used to supply ER Program input to the Hanford Mission Plan (DOE/RL 1991), and will provide direction to technology development activities being performed on a national and site level.

The baseline technologies identified in this plan are considered to be the minimum technologies required to ensure the success of the ER mission to investigate and remediate past-practice waste sites and, as such, are the technologies that will be supported with Hanford ER Program funding. All baseline technologies must meet the criteria discussed in Section 1.3.

The baseline technologies will be modified or changed, as needed, as a result of land-use decisions, feasibility studies, requirements identified by a Hanford Remedial Action - Environmental Impact Statement (HRA-EIS), and innovative technologies that are shown to be faster, less expensive, preferable, and/or safer. This plan will be updated annually to reflect these changes.

Potential baseline technologies are technologies that are potential improvements over baseline technologies, based on the criteria specified in this document, but that require engineering testing or research and development prior to being implemented. Funding by the ER Program for testing and/or development of these technologies will be allocated in order of priority, as determined by the criteria and evaluation procedure outlined in Section 5.0 of this plan.

1.1 PURPOSE AND SCOPE OF DOCUMENT

This document identifies baseline technologies to investigate and remediate past-practice waste sites at the Hanford Site and to meet Tri-Party Agreement milestones. The past-practice waste sites include: surface soils, cribs, trenches, tanks, burial grounds, decommissioned facilities, contaminated groundwater, and other intentional and nonintentional disposal sites.

The purposes of this document are to:

- Identify preliminary baseline technologies to investigate and characterize past-practice waste sites at Hanford and discuss potential improvements
- Identify a preliminary technology baseline for the remediation of past-practice waste sites at Hanford
- Outline engineering needs for baseline remediation technologies
- Give examples of potential baseline remediation technologies
- Identify development and remediation plans/activities funded by the Hanford ER Program in FY92
- Present a procedure to assess baseline technologies (specific vendors) and establish a method to assess and prioritize technologies to develop or test that may be an improvement over baseline technologies.
- Establish criteria for technology transfer and implementation.

This document applies only to remediation activities and technology development programs within the ER Program (EM-40) at the Hanford Site. It does not identify a baseline cleanup plan for the double-shell or single-shell tanks in the 200 Area, nor does it include activities within the scope of Office of Technology Development (EM-50) or Waste Operations (EM-30) programs.

1.2 BACKGROUND FOR PRELIMINARY ENVIRONMENTAL RESTORATION TECHNOLOGY BASELINE

Baseline investigation technologies identified in this document are technologies that are currently used at the Hanford Site as part of the remedial investigation phase I site investigations process under the CERCLA program.

Baseline remediation technologies are based on the *Hanford Past-Practice Site Cleanup and Restoration Conceptual Study*; hereinafter referred to as the macroengineering study (WHC 1992b). The study is currently being assessed by the U.S. Department of Energy (DOE) U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology). While the macroengineering study focuses on a large-scale approach to cleanup, technologies and systems described within the study are equally applicable to the Hanford Site past-practice investigation strategy outlined in the Tri-Party Agreement (Ecology et al. 1991).

1.2.1 Past-Practice Strategy

During 1991, the Tri-Party Agreement was amended to include the *Hanford Site Past-Practice Investigation Strategy* (DOE-RL 1991). This approach is intended to streamline schedules, integrate CERCLA RI/FS and Resource Conservation and Recovery Act (RCRA) past-practice RCRA feasibility investigation/corrective measures study (RFI/CMS) guidance, and reduce costs associated with investigating and characterizing operable units. The past-practice strategy includes grouping operable units into aggregate areas and performing limited field investigations, ERA, and/or interim response measures (IRM).

ERA means an onsite response action to abate a threat to human health or welfare or the environment that is not intended as a final remedial action. The IRM is an interim remedial action conducted at a CERCLA site at any time prior to the final decision. An interim decision is required to implement an IRM (Ecology et al. 1991).

The past-practice strategy is, in part, an implementation of the observational or "learn-as-you-go" approach to obtaining information about a site. The approach involves limited field investigations to decide on an appropriate ERA or IRM; and obtaining additional data as a part of interim removal activities to make final decisions (Wallace 1991). This approach was implemented at the Hanford Site in ERA removal activities conducted at the 618-9 Burial Grounds and 316-5 Process Trenches.

1.2.2 Macroengineering Study

The macroengineering study (WHC 1992b) describes conceptual systems to facilitate a large-scale observational approach to clean up the Hanford Site. In the study, complete systems are described for remediation of past-practice waste sites in the 100 Area and 300 Area, and for site-wide remediation of groundwater. Remediation systems are considered for industrial use cleanup limits, and residential limits (WAC 173-340, Model Toxics Control Act).

The macroengineering study is not a feasibility study nor will it replace a feasibility study. Rather, it identifies mostly commercially available systems that serve as a preliminary baseline to compare other plans and systems against, and provides a conceptual plan to remediate all of the designated past-practice waste sites at the Hanford Site.

The macroengineering approach consists of using large-scale equipment to retrieve contaminated material from waste sites in the 100 and 300 areas, limited processing to reduce waste volumes, and disposing contaminated material in a disposal facility in the 200 Area. By removing contaminated material to a safe location in the 200 Area, the 100 and 300 areas could be released for public use or further industrial use. Most 200 Area waste sites and the disposal facility would be stabilized in situ as needed. Caps or barriers would then be placed over these sites to ensure long-term protection. The study describes an observational approach to obtain data during the retrieval process.

In the macroengineering studies, three scenarios were investigated for groundwater remediation, these include: 1) providing institutional controls to prevent groundwater from entering the Columbia River, 2) applying pump and treat technologies and isolating 200 Area groundwater, and 3) conceptual in-situ treatment and aquifer excavation technologies to cleanup groundwater by the year 2018.

IRMs that demonstrate macroengineering concepts are being planned for the 100-B/C Area and the 300-FF-1 operable unit. Implementation of these activities is contingent on funding and acceptance by DOE, EPA and Ecology.

1.3 CRITERIA FOR BASELINE

Remediation baseline technologies were selected using the criteria shown in Table 1. The second column of the table is an indication of the relative importance of the criteria, i.e., whether the criteria is essential to the baseline (required) or a desired feature (desired).

Table 1. Criteria for Selecting Baseline Remediation Technologies.

Criteria	Importance	Objective
Commercially available, and proven for desired applications	Required	Available for timely implementation
Effectiveness	Required	Meets cleanup goals
Cost/benefit ratio	Desired	As low as possible
Safety	Required	As low as reasonably achievable
Pilot and full-scale development needs	Desired	Minimal
Engineering design needs	Desired	Minimal/straightforward
Reliability	Required	High
Schedule/timed implementation	Required	Meets milestones
Capital investment	Desired	Moderate
Regulatory acceptability	Desired*	High probability
Public acceptability	Desired	High probability

* Refer to Section 1.3 to explain why this criterion was not required

The first consideration for selecting baseline technologies was whether the technology was available and proven for field implementation or could be engineered or modified to be implemented when it is needed. In this plan, baseline technologies identified for field investigations are those technologies currently in use at the Hanford Site.

Baseline remediation technologies were selected that were determined to be proven technologies for the intended application (i.e., previously used for similar applications), and that could support an interim decision before November 1994 for an IRM.

High probability of regulatory and public acceptability were desired criteria for selecting baseline technologies. The only reason they were not required criteria is because it was determined that a technology may achieve greater acceptability as it is further developed and demonstrated, and final regulatory decisions to accept or reject a technology are not made until final feasibility studies are conducted.

2.0 BASELINE INVESTIGATION TECHNOLOGIES AND POTENTIAL IMPROVEMENTS

Baseline technologies for field investigations are those technologies that are currently used in remedial investigation phase I CERCLA activities at the Hanford Site. Major types of investigations are shown in Figure 1. Descriptions of these investigations, technologies used, and procedures for performing field investigations at the Hanford Site are described in the environmental investigation instructions (EII) in the Environmental Investigations and Site Characterization Manual (WHC 1988), and in A Compendium of Superfund Field Operations Methods (EPA 1987).

Baseline technologies, examples of potential technology improvements, dates for when technologies are needed, and current development activities are summarized in Table 2.

Remedial investigations are performed as the first step of the RI/FS process under CERCLA (EPA 1988). To date, remedial investigation phase I work plans have been approved for four operable units: 1100-EM-1, 300-FF-1, 300-FF-5, and 200-BP-1. Investigations for these operable units are being conducted in accordance with the work plans. Field investigations in the 1100 Area have been completed.

Investigations in the 300-FF-1, 300-FF-5, and 200-BP-1 operable units are ongoing and are scheduled to be completed during FY 93. Other 200 Area and 300 Area work plans either have not been initiated or are being developed. The Tri-Party Agreement requires that work plans for six operable units or aggregate areas be submitted each year. Therefore, work plans will be developed, and field investigations are scheduled to continue for about the next 10 yr.

Draft work plans have been submitted to the U.S. Department of Energy-Richland Field Office (DOE-RL), Ecology, and EPA for most of the 100 Area. The work scope of these plans was redefined in aggregate area work plans for operable units in the 100 Area. Limited field investigations outlined in the aggregate area work plans are in progress and are expected to be completed by FY 93 for all of the 100 Areas.

While many of the remedial investigation phase I investigations are scheduled to be completed within a few years, recommended improvements such as real time screening and use of mobile laboratories will be needed for many years thereafter in support of remediation, post-remediation sampling, and monitoring activities.

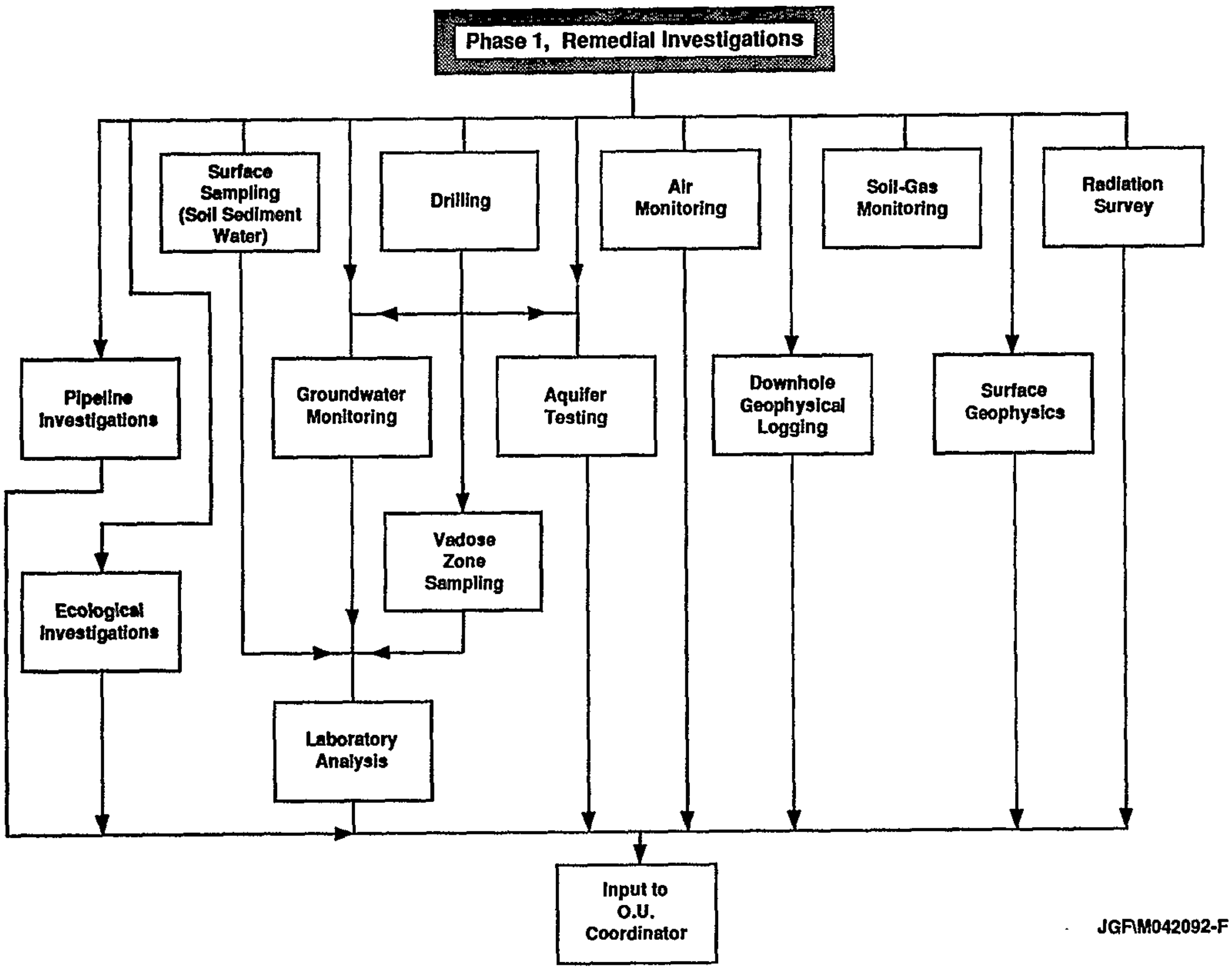

Figure 1. Major Types of Field Investigations within the Hanford Environmental Restoration Program.

Table 2. Baseline Investigation Technologies and Examples of Improvements.

Type of investigation	Baseline technologies	Examples of potential improvements	Priority for improvement	Improvement activities[1]
Radiation surveys	Portable beta/gamma detectors Ultra-sonic ranging and data system Road monitors	Aerial surveys in open areas	Low priority	OTD[2]
Surface sampling (soil, water, structures)	Intrusive sampling techniques followed by laboratory analysis Table 3 instruments	Calibrate and field test instruments for screening samples and in-situ monitoring	High priority	X-Ray fluorescence (sec 2.2.1) Mobile laboratory (sec 2.13)
Surface geophysical surveys	Ground-penetrating radar Electromagnetic induction Seismic surveys Magnetic surveys	Improve instrument resolution Enhance data interpretation	Medium priority	OTD[2]
Down-hole geophysical surveys	Gross gamma-ray logging Spectral gamma-ray logging	gamma-gamma neutron-neutron neutron activation	High priority	OTD[2]
Air monitoring	Air monitors (Table 3) and particulate sampling	Increase instrument sensitivity, more investigations	High priority	CCl_4 expedited response action, OTD[2] (App. B)
Ecological investigation	Plant/animal surveys Vegetation sampling Lab analysis	Screening instruments	Medium priority	OTD[2]
Drilling	Cable-tool drills	Sonic drill ODEX rotary drill Angle/horizontal drilling	Medium priority	Sonic drilling, OTD[2] (VOC-Arid ID Site, App. B)
Aquifer testing	Well draw down tests Slug tests	Technologies to minimize water volumes generated	Medium priority	None, interference slug testing is being investigated
Groundwater monitoring	Pump wells, obtain samples, and send to laboratory for analysis	In-situ sampling	High priority	None
Soil-gas monitoring	Insert sample tubes, draw samples, send to laboratory	In-situ soil-gas sampling Increased depth of soil-gas samples	Medium priority	Cone penetrometer tests, OTD[2], (VOC-Arid ID Site, App. B)
Vadose zone sampling	Drill Boreholes, split spoon or other sampling technique, send samples to lab	Reduce need for boreholes, and intrusive sampling by using downhole geophysical techniques, cone-penetrating testing, and/or screening instruments	High priority	OTD[2] Mobile Laboratory (sec. 2.13)
Pipeline investigations	Locate breaches or leaks in underground pipelines using helium injection and detection	Remote application of Thermal Infrared Sensors, corrosion logging	Medium priority	OTD[2]

1 All types of investigations are in progress and are projected to continue at the Hanford Site for up to 10 yr.
2 Being addressed by one or more U.S. Department of Energy Office of Technology Development activities.

2.1 RADIATION SURVEYS

2.1.1 Baseline Technologies

Portable beta/gamma radiation detectors are commonly used by Health Physics Technicians to survey land areas in operable units. Most of the surveys are conducted using portable field instruments. One instrument that has been successfully tested onsite and is being used for many of the current radiation surveys conducted at Hanford CERCLA sites is the Ultra-Sonic Radiation and Data System (USRADS). Road monitors (vehicle mounted sensors) are also available for use as needed. While the road monitors cover more area in a shorter period of time, they are generally less sensitive than portable field units. More frequent surveys are required near radiation zones to ensure that contaminants have not spread. Aerial gamma surveys of the Hanford Site are also available.

2.1.2 Potential Improvements

A potential improvement to current methods for radiation surveys may be to mount radiation detectors in helicopters to survey a large area of land in less time, and with less potential worker exposure. The utility of this application would be limited primarily to open areas, due to the shine from highly contaminated facilities, and would be contingent on sensitivities of the instruments used.

2.2 SURFACE SAMPLING

2.2.1 Baseline Technologies

Surface soils, sediment, and surface water are sampled using techniques identified by WHC (1988). These are intrusive samples that are collected, placed in approved containers, packaged, and shipped offsite to analytical laboratories as described by WHC (1988).

Many soil and water investigation techniques have been identified that may be used to reduce the cost of surface soil and water investigations, and reduce the volume of samples that are shipped to laboratories. Field screening instruments that have been used at the Hanford Site for analysis and monitoring are shown in Table 3.

An X-ray fluorescence (XRF) instrument was used to screen for metals of concern in samples collected from the 300-FF-1 operable unit. The data obtained will be compared with laboratory analyses. Initially, the results appear favorable and Westinghouse Hanford Company (WHC) field engineers indicate that the portable XRF is ready for field implementation. The 300-FF-1 data is being further analyzed to determine if XRF can be used to detect chromium in the soils. XRF laboratory analyses are provided by Pacific Northwest Laboratory (PNL) and are being used to analyze bulk soil samples, and sieved soil samples.

Table 3. Field Screening Instruments Available for Use in the Westinghouse Hanford Environmental Division. (sheet 1 of 2)

Compounds	Samples/Method	Instrument	Comments
combustible gas	real-time monitoring	Ind Sci MX251/LD222/TMX410[a] Bacharach 503[b] MSA Model 62 CGI[c]	Provides onsite measurement capability with results available immediately or in a short turnaround time to support decisions associated with worker health and safety. Detection limits are consistent with personnel protection requirements
methane		Ind Sci TMX410[a] Bacharach 503[b] MSA Model 62 CGI[c] OVA 128[d]	
oxygen		Ind Sci MX251/TMX-410[a] Bacharach 503[b]	
H_2S / CO		Ind Sci TMX410[a]	
dust, aerosols		PPM Aerosol Monitor[e]	
chlorinated compounds		TRI Odyssey 2001[f]	
organic vapors		OVM 580-B[g] SIP 1000 (PID/FID)[d] HNu 101[h] OVA 128CG[d] Sentex GC (AIS/ECD)[i]	
mercury vapor		Jerome 431X Hg vapor analyzer[j]	
misc gases and vapors		Draeger tubes[k]	
heavy metals in dust		X-Met 880 (air filters)[l]	
volatile organics in air or soil gas (including fuels and chlorinated solvents)	direct measurement	OVM 580-B[g] HNu 101[h] SIP 1000 (PID/FID)[d]	Total organic vapor concentration. Detection limit in low ppm range (better for some compounds)
		OVA 128GC[d]	Total organic vapor concentration. Detection limit in low ppm range. Ambient-temperature GC capability for compound separation
		TRI Odyssey 2001[f]	Responds to chlorinated hydrocarbons only. Detection limit in ppb range
	tedlar bags glass vials sorbent tubes	Sentex GC (AID/ECD)[i] SRI 8610 GC (PID/FID/ECD)[m]	Provides identification and quantification of individual compounds. Detection limit in low ppm range or better

Table 3. Field Screening Instruments Available for Use in the Westinghouse Hanford Environmental Division. (sheet 2 of 2)

volatile organics in soil	dynamic headspace (shake and sniff)	HNu 101[h] SIP 1000 (PID)[d] OVM 580-B[g]	Results are qualitative: used primarily to evaluate fuel contamination in soils at underground storage tank excavation
volatile organics in soil or water	equilibrium headspace	SIP 1000 (PID)[d]	Total organic vapor concentration results are semiquantitative in soils. Detection limit is compound-specific
		OVM 580-B[g]	
		TRI Odyssey 2001[f]	Responds to chlorinated hydrocarbons only. Detection limits in ppb range
		Sentex GC (AID/ECD)[i]	Provides identification and quantification of individual compounds. Detection limit in low ppm range or better
	purge and trap	SRI 8610 GC (PID/FID/ECD)[m]	
	thermal stripping		
semivolatile organics in soil or water			
mercury in soil	headspace	Jerome 431X mercury vapor analyzer[j]	Highly specific for mercury
heavy metals	in-situ measurement	X-Met 880 portable XRF analyzer[l]	Detects any element with atomic number greater than Titanium-22. Results may be qualitative or quantitative, depending on instrument set-up and calibration. Detection limits are 100-500 ppm
heavy metals in soil	samples (shake & bake)		
heavy metals in water	samples		
lead paint	in-situ measurement		
various contaminants and waste characteristics	samples	HAZCAT kit[n] HACH chromium kit[o]	Contains a series of indicator tests that provide qualitative or quantitative indications

[a] Industrial Scientific Corp. (Oakdale, PA)
[b] Bacharach, Inc. (Pittsburgh, PA)
[c] Mine Safety Appliance Co. (Pittsburgh, PA)
[d] The Foxboro Co. (Foxboro, MA)
[e] PPM Enterprises, Inc. (Knoxville, TN)
[f] Transducer Research Inc. (Naperville, ILL)
[g] Thermo Environmental Instruments, Inc. (Franklin, MA)
[h] HNU Systems, Inc. (Newton, MA)
[i] Sentex Sensing Technology, Inc. (Ridgefield, NJ)
[j] Arizona Instruments Corp. (Tempe, AZ)
[k] Dragerwerk Ag Lubeck (Germany)
[l] Outokumpu Electronics (Espoo, Finland)
[m] SRI Instruments (Torrance, CA)
[n] HazTech System, Inc. (San Francisco, CA)
[o] Hach Company

HACH Kits are being used to screen soils for hexavalent chromium in the 100 Area. It has been found that iron concentrations in soils at the Hanford Site often must be diluted to screen for chromium. Therefore, a HazCat Kit for chromium has also been used for the 100 Area and 300 Area chromium screening and tends to provide better results.

2.2.2 Potential Improvements

While all of the instruments shown in Table 3 have been used, additional calibration and testing of these and other instruments is needed to screen for specific constituents and achieve required detection limits. Screening instruments are needed to detect isotope specific low level radioactive constituents, inorganic contaminants (especially uranium and hexavalent chromium), and organic contaminants.

2.3 SURFACE GEOPHYSICAL SURVEYS

2.3.1 Baseline

Currently, one or more surface geophysical techniques are used to characterize cribs, trenches, and burial grounds to locate buried pipes and to better define subsurface features. Surface geophysical survey technologies used at the Hanford Site and their applications are shown in Table 4.

While the surface geophysical techniques used at the Hanford Site detect objects or anomalies in the ground, data obtained cannot generally be used to determine the type of object detected or the depth of the object.

Table 4. Surface Geophysical Survey Technologies at the Hanford Site.

Survey technology	Application
Ground-penetrating radar	Routinely used to detect waste materials or subsurface structures (trenches, tanks, drums, etc.) in which materials were deposited at a depth of 10 m or less. It is also used to detect natural features (e.g., bedrock, the water table, voids and sedimentary interfaces).
Electromagnetic induction	Detect metal objects or collections of objects. Landfills are the prime targets for the electromagnetic induction surveys. Electromagnetic induction can be used for shallow soils or depths up to 50 m. The maximum depth depends on soil type.
Seismic surveys	Determine subsurface configurations. Information can be obtained in excess of 1,000 m depths. Explosive techniques are not used for Hanford Environmental applications. Other seismic survey techniques are practiced infrequently.
Magnetic surveys	Detect subsurface ferromagnetic materials, or to enhance and complement their detection using other methods. This technology is also used to detect natural features (e.g. basalt bedrock, faults in bedrock, etc.) which may influence groundwater flow paths. Depth penetration is good to over 1,000 m.

2.3.2 Potential Improvements

Potential improvements to baseline surface geophysics technologies include increasing instrument resolution, increasing depth penetration, and enhancing data interpretation.

2.4 DOWNHOLE GEOPHYSICAL LOGGING

2.4.1 Baseline

Several downhole geophysical logging instruments are used to characterize vadose zone soils, and reduce the number of soil samples required.

Gross gamma-ray logging and spectral gamma-ray logging are used primarily to detect radiation contamination zones. They are also used to determine subsurface lithology of vadose zone and/or groundwater boreholes. Gross gamma-ray logging may be used in both dry holes and water-filled boreholes, but it provides only total gamma information.

Spectral gamma-ray logging can be used in steel cased or water-filled boreholes and provides nondestructive assays of isotope specific gamma-ray emitting nuclides. WHC has developed a state-of-the-art spectral gamma-ray technology that is in high demand to provide isotope specific borehole logging information from vadose zone drilling throughout the Hanford Site.

2.4.2 Potential Improvements

Commercially, several companies collect gamma-gamma and neutron-neutron log data. These technologies are currently lacking at the Hanford Site, but are required in the 200-BP-1 work plan, and are being investigated.

During March 1991, additional testing and development of gamma-gamma and neutron-neutron technologies was recommended by a geophysics review committee consisting of Hanford and non-Hanford personnel. These tests would include field demonstrations of instruments as well as calibration activities and modeling.

Neutron-activation logging has long been considered for use at the Hanford Site. This would be used in a manner similar to spectral gamma logging, to detect non-gamma emitting radionuclides such as ^{238}U, ^{14}C, ^{90}Sr, and ^{99}Tc. Neutron-activation logging also has potential as a site characterization and monitoring tool for nonradioactive contaminants of concern including nitrate, chromium, cadmium, copper phosphates, and cyanides.

The geophysics committee and DOE-RL recommended that the feasibility of using neutron-activation logging at the Hanford Site be tested to determine if defensible data can be collected and, if successful, aggressively pursued. To date, schedules or plans to develop this technology have not been developed.

2.5 AIR MONITORING

2.5.1 Baseline

Air investigations are performed to identify VOC and particulates in the atmosphere to ensure worker safety during operations. Many of the field instruments used for screening samples (Table 3) are also used for air monitoring. Instruments used for detecting volatile compounds include organic vapor meters, photoionization detectors, combustible gas monitors, oxygen monitors, flame ionization detectors, and draeger tubes.

High volume air samplers are used to sample for airborne particulates. After sampling, air sample filters are sent to the laboratory for analysis. The types of particulates analyzed for will depend on the constituents of concern at a site.

2.5.2 Potential Improvements

Additional air monitoring needs have been identified in support of carbon tetrachloride ERA. These include obtaining improved sensitivity of instrumentation, and performing more extensive air sampling and monitoring activities, in areas where VOC are suspected. Infrared instrumentation has been identified as a potential technology improvement for air monitoring at the Hanford Site. Studies to further assess air investigation needs are being conducted as part of the ERA.

2.6 ECOLOGICAL (BIOLOGICAL) INVESTIGATIONS

2.6.1 Baseline

These investigations include qualitative animal surveys to verify established species lists, vegetation surveys to delineate plant community types and compile species inventories within each community type, and vegetation sampling. Plant and animal surveys only consist of documenting site conditions. Vegetation sampling involves selecting locations to be sampled, clipping vegetation, then prepared and packaged to be shipped for analysis as specified by WHC (1988).

2.6.2 Potential Improvements

As for other forms of intrusive sampling, real time nonintrusive screening technologies would reduce the number of samples collected and the cost of vegetation sampling.

2.7 DRILLING

2.7.1 Baseline

Groundwater monitoring wells and vadose characterization borings are constructed to assess/monitor groundwater and obtain data regarding a site or sites. At the Hanford Site, these borings are drilled using a cable-tool drilling rig. This is used to maintain sample integrity, minimize secondary waste, provide contamination controls, and minimize in-situ cross contamination.

2.7.2 Potential Improvements

While cable-tool technologies provide good sample integrity and contamination control, users recommend investigating other more efficient, less costly drilling technologies. Recently, a sonic drill was tested at the Hanford Site. The sonic drill maintains the attributes of the cable-tool drill, but is significantly faster. Sonic drill rigs are being used more onsite, and performance testing of sonic drilling is being conducted as a part of the VOC-Arid integrated demonstration (ID).

The ODEX drill is a rotary drilling process that has been used onsite. The ODEX drill does not maintain the same contamination controls as the cable-tool and sonic drills, but is used for drilling groundwater wells in clean (background) areas.

Angle drilling and horizontal drilling technologies may be required to investigate soils and/or groundwater under large structures, burial grounds, and tanks, and/or to enhance remediation technologies such as vapor extraction. These technologies must be tested onsite before implementation.

2.8 AQUIFER TESTING

2.8.1 Baseline

Aquifer testing is conducted to determine the hydraulic characteristics of confined or unconfined aquifers. Two methods are used at the Hanford Site: 1) a well drawdown and recovery pumping test and 2) slug tests.

Well drawdown pumping tests are single or multiple well tests, and the volume of water generated during these tests (purge water) may be as high as 1-M gal/d. These types of tests are required to determine aquifer characteristics over a large area.

In the slug test the water level in a well is instantaneously changed by inserting, removing, or displacing a known volume of water. The water level response is then monitored over time in a single well. The advantage of this test is that no contaminated groundwater (purge water) is generated during testing. The disadvantage of slug testing is that it only covers a small radius of influence and limited information is provided.

For all well development, aquifer test activities, and groundwater sampling the generation of water is of primary concern especially when wells are developed in areas where groundwater is highly contaminated. This is because contaminated water, exceeding regulated levels, must be contained. Contaminated water is currently contained in a 1-M gal unit designed to facilitate solar evaporation. A second unit is available as a backup. Nonetheless, these units do not provide sufficient capacity for aquifer tests. Therefore, without approval by Ecology, aquifer tests are currently limited to being performed only in noncontaminated areas (DOE-RL 1990).

2.8.2 Potential Improvements

Technologies are needed to perform aquifer tests, develop wells, and sample wells using methods such that a minimum volume of water is removed from the well. Interference slug testing is one such technology that is being investigated for use at the Hanford Site.

2.9 GROUNDWATER MONITORING

2.9.1 Baseline

More than 600 monitoring wells are in place at the Hanford Site for monitoring programs. Additional RCRA groundwater monitoring wells are being installed at the rate of 50/yr, as mandated in the Tri-Party Agreement (Ecology et al. 1991), milestone M-24-00.

After wells are completed, groundwater is monitored monthly to annually. This is done by measuring water levels, pumping to purge the well, obtaining samples, and preparing them to be sent to the laboratory.

Water levels are measured using a calibrated steel measuring tape, electric sounder, or continuous recording device. The steel tape is the most accurate of the three methods. An electric sounder is less accurate and is used for indication purposes only, or is followed by steel tape measurements. The continuous recording device is used to record changes in the water level over a continuous period of time. It consists of a float-balance type device or pressure-transducer device connected to a recorder. The recorder must be checked using the steel tape method, at a minimum each time the recording chart is changed.

Groundwater well samples are obtained by preparing the well using a submersible or non-submersible pump and pumping 3 borehole volumes to purge the well. Separate samples are collected to analyze for:

- Volatile Organics (VOC)
- Total Organic Halogens (TOH)
- Total Organic Carbon (TOC)
- Semivolatile Organics
- Other Unfiltered Samples
- Filtered Samples.

Filtered samples are collected last. A teflon bailer is used to collect samples in wells with a submersible pump or no pump. Some piezometer tubes are sampled by the air-lift method in which sample water is pushed up and out of the well by compressed air. This method is not and can not be used to sample for VOC, TOH, or hydrogen. The samples are typically placed in a ice chest, prepared for shipping, and transported to an appropriate analytical laboratory.

2.9.2 Potential Improvements

Potential improvement to water level measuring methods may include using bubblers in shallow wells or other types of pressure-transducers to reduce potential exposure and decontamination needs using the steel tape. In general, continuous recorders are cost prohibitive if measurements are only needed monthly or less frequently.

In situ sampling and analysis techniques would reduce the volume of water generated, reduce the number of samples that are sent to the lab, and may provide quicker data analyses or real-time data.

Improvements in well design for longevity and function are also being investigated.

2.10 SOIL-GAS MONITORING

2.10.1 Baseline

Soil-gas sampling is a screening tool used to detect and evaluate VOC in the vadose zone and/or groundwater. Soil-gas monitoring is used to help select optimal placement of monitoring wells within the vadose zone.

Soil-gas sampling consists of inserting sampling tubes to a depth of 4 to 6 ft into the soil or water. Gas samples are then drawn through the sampling probes using a low volume pump. The samples are collected in bottles or bags and transferred for analysis. Samples are analyzed using gas chromatography and employing detectors with broad spectrum sensitivity (i.e., flame ionization or photoionization), and halogen selectivity (i.e., electron capture or Hall electrolytic conductivity).

Samples are often sent to offsite laboratories, but could be analyzed onsite if a mobile laboratory was available with the required instrumentation or portable field units.

2.10.2 Potential Improvements

Identification and determining the distribution of VOC in the subsurface is critical to the design and operation of vapor extraction systems. Currently, there is no technology at the Hanford Site for routinely collecting in-situ soil-gas samples during borehole drilling. Instead, soil samples that are brought to the surface may be screened at the drill site with a photoionization device or transferred to containers for subsequent analysis.

However, volatile organics may be easily lost from the sample by disturbance during drilling, sample retrieval, and/or sample handling. A potential instrument for in-situ soil-gas measurements is being investigated as part of the VOC-Arid ID site (Appendix A). Soil-gas sampling at depth may be achieved using a cone penetrometer. This technology is also being investigated.

2.11 VADOSE ZONE SAMPLING

2.11.1 Baseline

Vadose zone sampling consists of drilling boreholes or excavating test pits to obtain soil samples below ground surface and above the water table.

When test pits are excavated, surface sampling techniques are used (WHC 1988), samples are then placed in containers and packaged and shipped to the laboratory in accordance with WHC procedures.

The most common method of vadose zone sampling at the Hanford Site consists of using a cable-tool drill rig to drill to the desired depth, a split-spoon sampler or shelby tube is then driven to its sampling depth through the bottom of the borehole, and an undisturbed soil core extracted. This technique is especially useful in obtaining samples when VOC are among the analytes of concern. Other sampling methods are discussed in WHC (1988).

2.11.2 Potential Improvements

Potential improvements to current technologies include: 1) using downhole geophysical techniques, and 2) using other analytical screening techniques to reduce the number of samples required.

2.12 PIPELINE INVESTIGATIONS

2.12.1 Baseline

Current investigation to locate pipeline leaks or breeches involves helium injection to pressurize the pipe and detect helium at the ground surface. This method is generally accurate within a few feet of the pipe breach or leak.

2.12.2 Potential Improvements

Potential improvements to the helium injection method include using a helicopter for aerial thermal infrared sensing or applying logging tools to detect corrosion, pits, and splits in pipelines. Potential cost and/or technical advantages of these approaches should be investigated.

2.13 MOBILE LABORATORY

The baseline for sample analysis is to screen all soil and water samples onsite, and to send confirmation samples (5% to 10% of the samples) to contract laboratories to compare with and verify screening results. This approach requires implementation of a mobile laboratory onsite.

Design specifications have been developed to procure a mobile laboratory for the site. It is hoped that a contract will be awarded before the end of FY 92. It is intended that this laboratory be used to screen samples collected during investigations and remediation activities. In part, the mobile laboratory will be used as a 24-h turnaround laboratory to verify results from real-time field sensors that may be used on conveyors and handling equipment during remediation. The mobile laboratory will provide a variety of instruments to analyze for radioactivity, inorganic, and organic contaminants. Analytical results from the mobile laboratory will be compared with samples analyzed at contract laboratories.

3.0 BASELINE REMEDIATION TECHNOLOGIES

As stated previously, macroengineering studies provided the basis for selecting preliminary baseline remediation technologies. Although the systems and technologies presented in the macroengineering studies were selected for a large-scale cleanup approach, the technologies apply equally to the past-practice and aggregate area cleanup strategy described in the Tri-Party Agreement. The process, development, and rationale used for selecting baseline cleanup technologies is shown in Appendix A. Appendix A.3 identifies baseline and potential baseline remediation technologies. Figure 2 presents a block diagram of the technologies selected, and illustrates processes from initial characterization to final disposal.

The primary baseline elements for three Hanford Site remediation activities are discussed in this section. These include baseline technologies for: 1) excavation and retrieval in the 100/300 areas, 2) a disposal facility and remediation of waste sites in the 200 Area, and 3) a preliminary baseline approach for groundwater.

The technologies identified in this section are commercially available systems that are potentially implementable within a 3-yr period and serve as a preliminary baseline to compare with other plans and systems. These technologies are not selected methods of remediation. Final remediation methods and technologies will be evaluated as a function of feasibility studies, and will be identified in the record of decision.

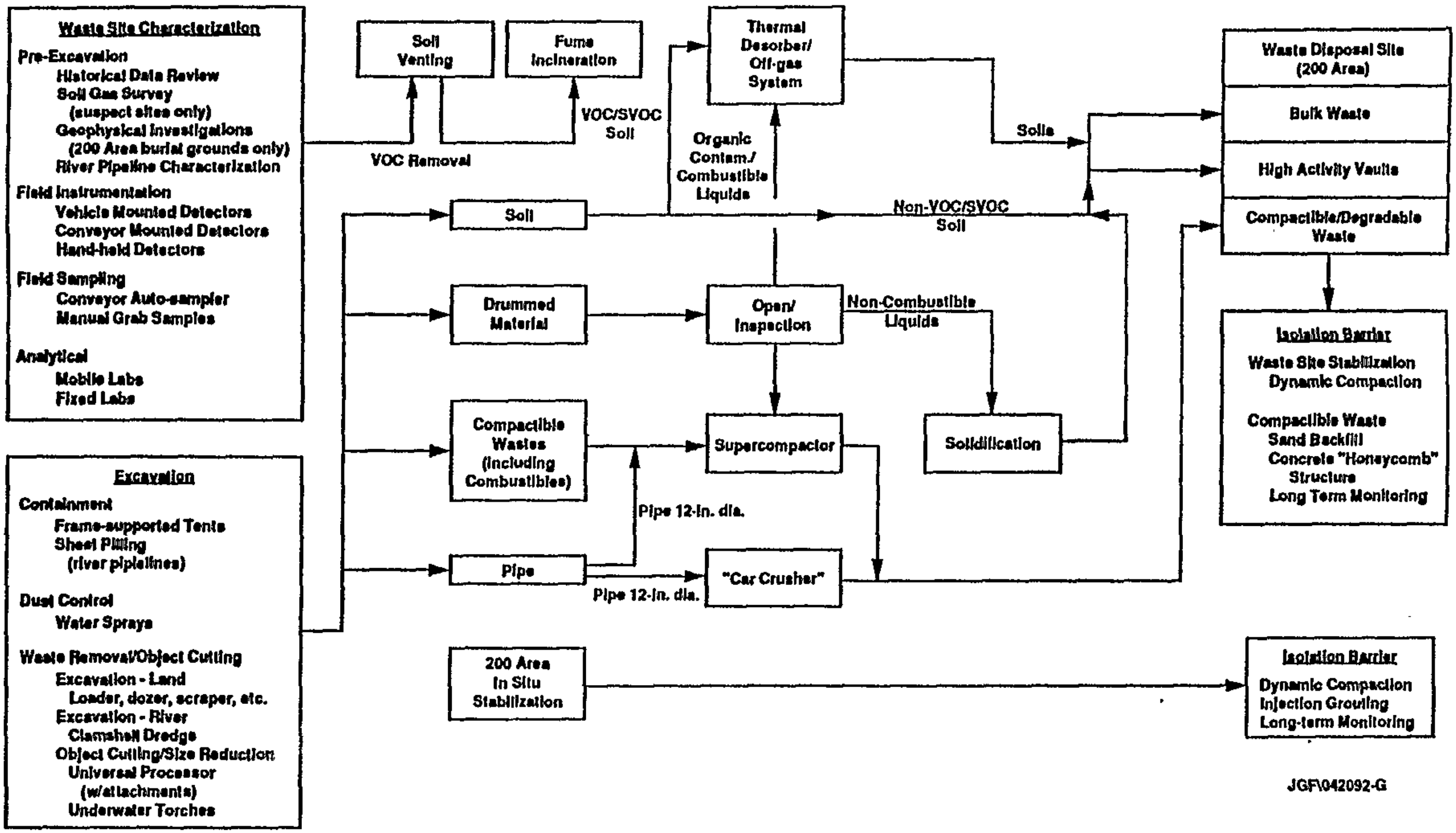

Figure 2. Baseline Cleanup Technologies Flow Diagram.

3.1 100/300 AREAS

3.1.1 Pre-Excavation Characterization

Much information is available about many of the 100 and 300 area sites. Data is available from current groundwater and vadose zone sampling and monitoring activities and from many historical sources. Therefore, a complete historical data review will be the first step in pre-excavation characterization.

Limited Field Investigation (LFI) activities described in Section 2.0 will then be performed. These investigations will be limited as much as possible per negotiation with state and federal regulatory agencies. The number of boreholes or test pits to be drilled will be minimized, fewer soil samples will be collected, soil-gas surveys will only be performed where VOC are expected, and surface geophysical investigations will be limited primarily to identify waste site boundaries such as trenches in the 100 Area and to locate underground piping.

Extensive characterization prior to retrieval is required for the Columbia River pipelines in the 100 Area. It is cost effective to sample these to determine if the level of contamination warrants removal of the pipe and what controls, if any, are needed to prevent contaminating the river.

3.1.2 Characterization/Sorting During Investigations

During waste excavation, hand-held, vehicle mounted and conveyor mounted radiation and VOC detectors would be used to determine waste composition and to sort different types of waste. Hand-held instruments would be limited to low activity sites. In particular, sorters will be required to effectively separate: soil from non-soil; clean material and clean overburden soil from contaminated material; Transuranic (TRU), high activity, and low activity waste; land disposal restricted (LDR) materials from non-LDR, and combustible from noncombustible waste.

Shallow soil cores, taken before backfilling, would be used to certify that a site is clean.

Mobile laboratories would be used to verify results of real-time equipment sensors. A maximum 24-h sample turnaround would be required. Ten percent of the samples screened by the mobile laboratory would be analyzed in contract laboratories with full quality assurance/quality control (QA/QC) for verification. Development of mobile laboratory capability for high activity radionuclides is needed.

3.1.3 Containment/Dust Control

Water sprays would be the primary means to control dust. Other dust suppressants such as fixants, binders, encapsulants, and polymers should be developed and tested for applicability. Equipment, such as the pavement profiler, that minimizes the generation of dust during excavation is being investigated for the 100-B/C Area demonstration.

Containment structures are costly and may limit production rates. Structures will only be used if required by a safety assessment of waste site operations. If structures are needed, negative pressure tents (frame supported) are the only suitable structures currently available.

For the river pipelines, sheet piling would be used to construct coffer dams if the pipes must be removed from the river and if soil sediments must be contained. Pipelines may also be decontaminated in place. This would reduce containment concerns associated with the removal of the river pipes.

3.1.4 Removal/Size Reduction

Loaders, dozers, backhoes, scrapers, trucks, and other machinery would be used to excavate on land. A clamshell dredge would be used if excavation in the river is required.

Excavation/processing equipment with interchangeable attachments such as shears, grapples, and crushers, would be used for object cutting and size reduction. If underwater pipelines need to be cut for removal, divers and hand-held cutting torches would be used.

For sites with dangerous levels of VOC in the vadose zone, in-situ venting would be used to remove the bulk of contamination. VOC contaminants that cannot be removed by venting would be treated after excavation by a thermal desorber system. Current information indicates that in-situ venting will probably not be needed in the 100 or 300 areas and that a thermal desorber will only be needed for small volumes of material.

3.1.5 Special Items/Engineered Modifications

Safety assessments may require that equipment operated in certain waste sites be equipped with shielding and supplied breathing air. However, these modifications will probably not be required for most sites.

Remote controlled vehicles would significantly reduce worker risk and exposure. Such vehicles have been developed and are used by the U.S Department of Defense. Application of remote equipment should be investigated and may be required at some sites.

Equipment such as "pavement profilers" that minimize airborne dust during excavation, but are not hydraulic excavation processes are being investigated.

3.1.6 Processing/Volume Reduction

Baseline technologies for volume reduction processes would include the following:

- Send organic contaminated solids to a thermal desorber system
- Send compactible materials (wood, pipe, cardboard boxes, etc.) to a supercompactor to reduce waste volumes

- Flatten large pipe (> 12-in. diameter) at the disposal facility using a 'car crusher' or similar device

- Intact drums (if any) would be opened, inspected, and contents sorted. Combustible liquids would be sent to an incinerator off-gas system (stage 2 of the thermal desorber system), other liquids would be solidified, and drum overpacks would be used as needed. Solids not contaminated with organics would be sent to a supercompactor. Those contaminated with organics would be sent to thermal desorber.

Solidification/stabilization (with grout or other suitable material) may be required to comply with Land Disposal Restrictions for soils or solid waste with toxic characteristic metal contaminants.

Other alternatives for processing waste include: shredding, incineration, and solidification. Studies are being pursued to further assess these technologies. In the baseline report (Appendix A) it was assumed that shredders may not perform adequately due to the presence of boulders in the solid waste stream, and that a mobile thermal desorber system with an off-gas incinerator could be implemented in a shorter time than an incinerator.

Application of physical separation/soil washing processes may substantially reduce the volume of soils that require disposal. However, these technologies are not yet proven for use at the Hanford Site. A physical separation process for soils will be tested in upcoming 300 Area treatability studies. Physical separation/soil washing should also be tested for potential application in the 100 and 200 areas.

The current baseline approach to remediate petroleum tanks regulated by the Underground Storage tank program is to remove the tanks, clean the tanks at an offsite location, and scrap the tanks after they are certified to be clean. If soils under the tanks are contaminated due to leaks or spills and petroleum/hydrocarbon compounds are the only contaminants of concern, the soils will be excavated and remediated using ex-situ bioremediation techniques (solid phase remediation). Bioremediation treatability tests have shown additional microbes are not needed at the Hanford Site. Thus, naturally occurring microbes are stimulated by adding water, nutrients (nitrogen source), and supplying oxygen. Aeration is provided by turning the soils at regular intervals.

3.1.7 Containers/Transportation

Rail flatcars would be used to transport waste containers to the 200 Area waste disposal site. Custom designed steel boxes with reusable overpacks would be used for containment. The optimum size for containers would be determined in further design studies. Containers would include both reusable and single-use types. Containers need design development.

Pipe racks with plastic covers would be used to transport large diameter pipe to the 200 Area disposal site. Dump trucks, excavation equipment, and belt conveyors would be used for local transport at the excavation site. Barges would be used to transport waste material to a railhead onshore for the river pipelines.

3.1.8 Site Restoration

Site restoration would consist of recontouring and revegetation of all disturbed areas. Soil would not be imported for backfill except as top soil to support vegetation.

3.2 200 AREA REMEDIATION AND DISPOSAL FACILITY

3.2.1 In-situ Treatment

Except for surface contaminated soils, past-practice waste sites in the 200 Area would be closed in situ.

As for the 100 and 300 areas, investigations would be limited. However, additional investigations may be required for in-situ disposal to establish site boundaries, to meet closure requirements, and to determine whether injection grouting is needed. Geophysical investigations would be used for characterizing the burial grounds and to detect voids in crib sites. Strategic soil sampling would be used to characterize 200 Area liquid waste disposal sites.

A soil-gas survey would first be performed where VOC are expected. If VOC are a safety problem at the site, vapor extraction technologies will be used. An extensive plume of carbon tetrachloride has been found in the vadose zone of the 200 Area. An ERA is in progress to remediate this plume.

If radionuclides or other chemical waste are in the vadose zone and large voids exist, waste sites would be stabilized. This would be accomplished by dynamic compaction. In those sites, such as burial grounds, where compaction alone may be insufficient to prevent future subsidence vibration-aided injection grouting would also be used. Both stabilization methods will require performance testing to show long-term subsidence can be controlled using these techniques.

Remedial techniques for handling tanks and tank waste (other than double- and single-shell tanks) in the 200 Area were not identified in the macroengineering studies (WHC 1992b). However, many tanks containing hazardous and radioactive waste exist. A preliminary baseline to remediate these tanks is to extract fluids, then stabilize tanks in place by dynamic compaction and vibration aided injection grouting.

In-situ vitrification (ISV) is a potential alternate stabilization method for cribs, burial grounds, and tanks that should be further developed. ISV is a process that will result in some volume reduction by eliminating combustible waste and organic compounds. It will also solidify and stabilize radioactive contaminants. Developments should be directed toward applications to compactible waste forms (such as in burial grounds) and increasing the depth of ISV probes.

3.2.2 200 Area Surface Soils

Hundreds of acres of low level contaminated surface soils (12 to 18 in. deep) are in the 200 Areas. The baseline cleanup technology for these soils is the same as that described for the 100 and 300 area sites; soils would be excavated, treated for VOC using a thermal desorber or solidified if required to meet land disposal requirements, and transported to the 200 Area disposal facility. Soils in the 200 Area would be transported to the disposal facility using covered haul trucks.

Soil washing is a technology that could be used to reduce the volume of surface soils requiring disposal; therefore, it should be included in 200 Area treatability tests.

3.2.3 Disposal Facility

The 200 Area disposal facility may occupy up to 3 mi^2. Bulk waste containers would be unloaded from rail flatcars with bridge cranes. The containers would be moved into a containment building provided for dust control. Container contents would be placed in the trenches and containers reused, except where safety assessments require disposing the waste and container to minimize potential exposure levels. Conveyors, cranes, forklifts, and/or trucks may be used to unload packaged waste from the railcars.

Low activity waste, high activity waste, and compactible waste would be placed in separate trenches. Low activity soils and compactible waste may need to be stabilized by injection grouting.

For permanent closure of compactible waste disposal trenches, a concrete 'honeycomb' type structure may be required to prevent long-term subsidence. Development of ISV, and incineration/melting or ex-situ vitrification are potential alternatives to this approach.

High activity waste would be placed in reinforced concrete vaults. The disposal facility would use a movable shielded metal building for dust control and to protect workers from potential exposure. TRU waste would be separated and stored for potential future retrieval and transport to another site.

3.2.4 Isolation Barriers

Final closure of all 200 Area waste sites would include emplacement of a RCRA cap or other conventional soil cap to ensure contaminants in the site will not migrate spatially, to air, or groundwater. Requirements for capping vary depending on the site to be disposed.

A "Hanford Site isolation barrier" has been designed for mixed waste and long-term isolation. Continued development to verify performance of the Hanford Site isolation barrier is described in Section 4.4. The Hanford Barrier differs from a RCRA cap in that it is designed to handle radioactive, as well as chemical waste. It has been specially designed for Hanford conditions, and consists of several layers for redundant protection against animal intrusion, wind, precipitation, and other factors. After a prototype has been developed and its performance tested, the Hanford Barrier would likely be used for the central disposal facility and for high activity in-situ disposal sites in the 200 Area.

The RCRA barrier, or other soil caps, may be sufficient for many of the sites. Compared to RCRA caps previously used at the Hanford Site, the Hanford Barrier is much thicker and requires more material; therefore, it may be more costly to implement. Types of soil caps to be used will be determined through performance assessments and feasibility studies.

3.2.5 Long-Term Monitoring

200 Area disposal facilities, and all waste sites closed as a landfill (anything other than clean closure), will require long-term monitoring to ensure adequate performance of the isolation barrier and stabilization method used. Subsidence monitoring will be conducted using lasers. Groundwater monitoring wells will be installed upgradient and downgradient of sites closed in situ, and groundwater will be monitored for a minimum of 30 yr (40 CFR 265 Subpart E) following in-situ closure of a site.

3.3 GROUNDWATER REMEDIATION

Macroengineering groundwater studies (WHC 1992a) evaluated the following three scenarios for large-scale remediation of Hanford aquifers:

- Protect the Columbia River by extracting groundwater in the 100, 300, 1100, and 600 areas; and injecting the extracted water back into the aquifer in the center of the Hanford Site. Institutional controls would be required in perpetuity, and Hanford Site groundwater would not be available for public use.

- Long-term cleanup of 100 Area and 300 Area groundwater may be accomplished by: 1) pumping groundwater plumes and treating extracted groundwater for all contaminants except tritium, 2) constructing slurry cut-off walls to isolate 200 Area groundwater, 3) constructing groundwater interception systems, and 4) injecting all tritiated water into the aquifer in the center of the Hanford Site. Groundwater beneath the 200 Area would not be available for use, and would require institutional controls in perpetuity.

- Clean up Hanford Site groundwater by 2018 by: 1) lixiviant-enhanced groundwater extraction of plumes (not currently available) in the 100, 300, and 1100 areas, followed by aquifer excavation where necessary, 2) constructing slurry cut-off walls and groundwater interception systems, 3) pumping plumes in the 200 and 600 areas, 4) treating extracted groundwater for all contaminants, including tritium, and 4) releasing treated water to the Columbia River.

The studies show that for all three scenarios, active aquifer remediation would be extremely costly ($10's of billions) and some of the component systems are not practical. For example:

- Pump and treat systems might require 100 yr or more to effect aquifer cleanup and it is possible that the sediments may never be adequately cleaned. Such approaches are not cost effective.

- To meet the 2018 milestone, aquifer sediments may have to be mined. Such mining is not practical or cost effective on this scale.

- There is no practical or cost-effective technology for removing tritium.

Even the most aggressive cleanup measures may result in a very small reduction in potential future risk. More so than any other remediation needs, a clear gap exists for baseline technologies to remediate groundwater. The lack of available cost-effective approaches to remediate Hanford groundwater underscores the need for development of workable and cost effective in-situ techniques such as chemical injection and bioremediation. These technologies should be aggressively pursued.

Evaluation of the risks and cost benefit of aquifer remediation is needed to determine what should be done. These studies are scheduled to be completed in FY 93. Until these studies are completed, the baseline is to continue monitoring (via wells) and to isolate groundwater (via institutional controls). Source removal/stabilization is an integral part of this action, since this would effectively reduce or eliminate contaminant transport from soils to the aquifer.

Acute/isolated groundwater contamination is not addressed by the macroengineering studies. Where isolated groundwater remediation is required the baseline technology is to pump and treat. Existing extraction wells will be used or new wells drilled to pump water. The water will be treated using filtration, ion exchange, iron coagulation, bio-denitrification, evaporation, selection liquid membranes, reverse osmosis, enhanced oxidation, and/or other applicable, commercially available, water treatment technologies. As for aquifer remediation, more effective technologies are needed.

3.4 ENGINEERING DESIGN AND TESTING NEEDED FOR BASELINE CLEANUP TECHNOLOGIES

This section identifies design and testing needs to support the baseline identified previously. While all of the baseline technologies are available, or are currently accepted technologies, some will require significant engineering design and/or performance testing prior to implementation. Major engineering design and testing requirements are shown in Table 5.

As specified by DOE (1987), a functional design criteria and conceptual design report shall be developed to determine design requirements and specifications for baseline technologies identified.

Table 5. Engineering Requirements for Baseline Technologies.

Requirement	Design/ analysis	Modify equipment	Construct	Performance testing
200 Area waste disposal facilities	X		X	X
Low temperature thermal desorption		X		X
Develop mobile laboratories with radioactive screening capabilities	X	X	X	
Real time systems for sorting transuranic/low-level waste bulk materials, and conveyor radiation and organics detectors	X	X		X
Excavation and pre-excavation detector arrays to identify waste site boundaries (depth and extent of excavation required)	X	X		X
Transport containers for re-use, and disposal, shielding and pipe racks	X	X	X	X
Containment structures and support systems	X	X	X	X
Equipment cab shielding, ventilation, and safety systems (includes systems or controls to reduce dust during operations)	X	X		X
Confirmation monitoring at disposal sites	X	X		X
Verify the use of dynamic compaction and vibration-aided injection grouting for long term isolation and subsidence control				X
Barrier systems	X		X	X
Solidification/stabilization of liquids and solids	X			X

3.5 POTENTIAL BASELINE REMEDIATION TECHNOLOGIES

Technologies shown in Table 6 are not included as baseline technologies because they are not currently available for use at the Hanford Site; some are still under development and others have not been tested for the desired application. Therefore, applied engineering and science programs conducted in support of ER Program activities should consider the technologies shown in Table 6.

This Table includes only a few potential baseline technologies that have been assessed previously (Appendix C). Other technologies not listed may also improve on the baseline. As additional technologies are identified or proposed they will also be assessed. A method used to evaluate and prioritize these technologies is discussed in Section 5.0.

Table 6. Potential Baseline Remediation Technologies Assessed in this Document (Appendix C).

Technology	Development or Testing Needed	Priority and schedule	Hanford ER Program planning/activities funded in FY 92
Field screening instrumentation for radiation, chemical, physical, criticality detection	Engineering/Science: Calibration testing and/or design of real time and mobile laboratory screening instruments	High priority, 0-15 yr[a]	See Section 2.2, also 100-B/C Demonstration
Binders, encapsulants and/or polymers for dust control	Engineering/Science: Test/Develop for more effective dust suppression, and to replace structural containment	Medium priority 4-15 yr[b]	100-B/C Demonstration
Remote controlled excavator and other automated equipment	Engineering: Enhance/modify equipment to reduce potential exposure levels to workers. Remote control excavators are being developed by major construction equipment companies	Medium priority 4-15 yr[b]	100-B/C Demonstration
Physical separation/soil washing	Engineering: Treatability tests on Hanford soils to reduce waste volumes; may include selection of reagents	High priority 2-15 yr[c]	300-FF-1, Section 4.2
In-situ vitrification	Science/Engineering: Increase depth for potential use in 200 Areas and develop for compactible waste stabilization, and burial grounds	Medium priority 4-15 yr	None Current, ER Funding planned for FY '94
Incinerator/melter or ex-situ vitrification	Science/Engineering: Investigate and test as potential alternatives to compaction and disposal	Medium priority 4-15 yr	None Current, ER Funding for 100 Area Treatability Tests planned for FY '93
In-situ groundwater treatment technologies such as chemical injection or bioremediation	Science: Research and testing for isolated groundwater contaminants and potential sitewide groundwater remediation, if required	High Priority 6-15 yr[d]	See Appendix B
Hanford Isolation Barrier	Engineering/Science: Build a prototype barrier and instrument for performance tests. Continue performance studies.	High priority 4-15 yr[b]	Section 4.4

[a] Currently needed for investigations and ERA. While it is assumed that remediation will continue for 20 yr or more, any new developments should be implementable within 15 yr.
[b] These are potential improvements identified in support of the 100-B/C demonstration.
[c] An interim response measure is scheduled to begin in the 300-FF-1 operable unit in 2 yr.
[d] Assuming groundwater remediation will continue for 20 yr it must begin within 6 yr to be completed by year 2018, as required by the Tri-Party Agreement.

4.0 REMEDIATION PLANS/ACTIVITIES

This section includes a description and schedules for planned and ongoing engineering design, testing, and remediation projects funded in FY 92 by the Hanford ER Program to implement or develop the remediation baseline identified in this document.

All schedules shown are preliminary plans contingent on regulatory approval, availability of resources, and/or funding. The schedules are expected to change as cost account plans, design documents, and/or work plans are finalized.

4.1 100-B/C DEMONSTRATION

The purpose of this project is to demonstrate the macroengineering approach to site-wide cleanup. As currently planned, the demonstration will result in cleaning the 100-B/C Area.

The conceptual plan for this demonstration is as follows. Large-scale mining equipment and attachments will be used to retrieve and size material; and contaminants will be transported to a central onsite disposal facility. Clean overburden will be separated from contaminated material. If VOC are detected they will be treated using SVE, if necessary, and/or a mobile thermal desorber system. Sealed drums will be opened and contents removed. Compactible waste will be compressed using a supercompactor.

All waste will be transported to a central disposal facility via rail cars. It is currently anticipated that the disposal facility be located in the 200 Area. The disposal facility will consist of separate trenches for high- and low-activity waste. Retrieved TRU waste will be packaged and stored onsite in a designated and approved area until a decision is reached regarding final disposal of TRU waste.

The milestone for initiating a record of decision for the 100-BC-1 operable unit is December 1994 (DOE-RL 1992a). The baseline must be ready for field implementation within 15 mo after this date. The 100-B/C demonstration is scheduled to be completed by September 1997. Schedules for design, planning, and implementation activities are shown in Table 7.

The biggest time constraint for the 100-B/C demonstration is to design, obtain required documentation, and start construction on a disposal facility. A schedule for planning and implementation of the disposal facility is shown in Table 8.

4.2 300-FF-1 ACCELERATED CLEANUP PLANS

These plans consist of a physical separations soil treatability test to be planned and conducted in FY 92, an Interim Response Measure (IRM) to clean up 35 acres of contaminants in ponds and trenches, and three potential ERAs to retrieve waste from burial grounds (similar to the 618-9 ERA). Projected schedules for each of these activities are shown in Tables 9, 10, and 11. The ERAs were planned for FY 92, but are currently on hold.

Table 7. Schedule for 100-B/C Demonstration.

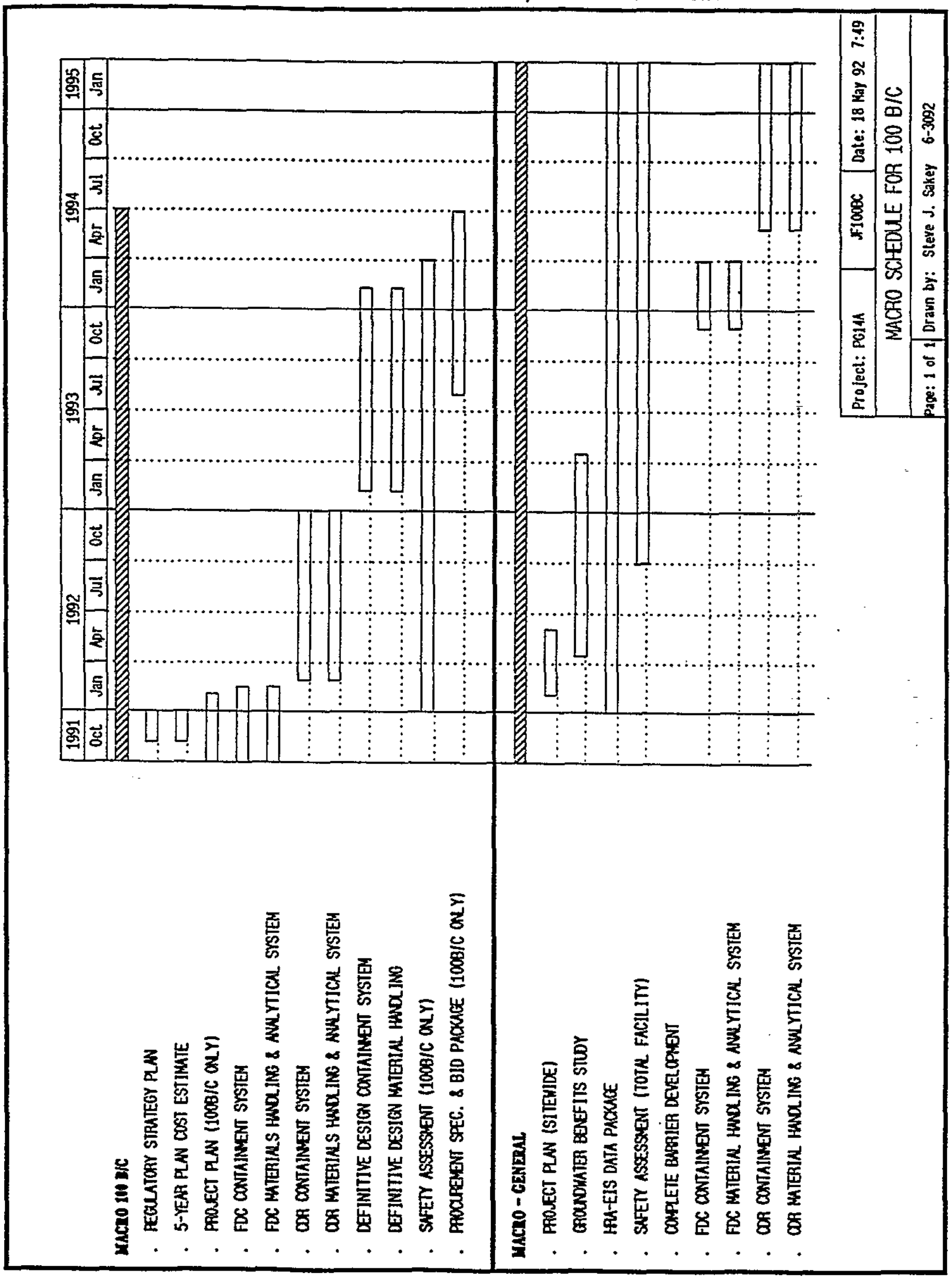

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Table 8. Schedule for Planning and Implementation of a 200 Area Disposal Facility.

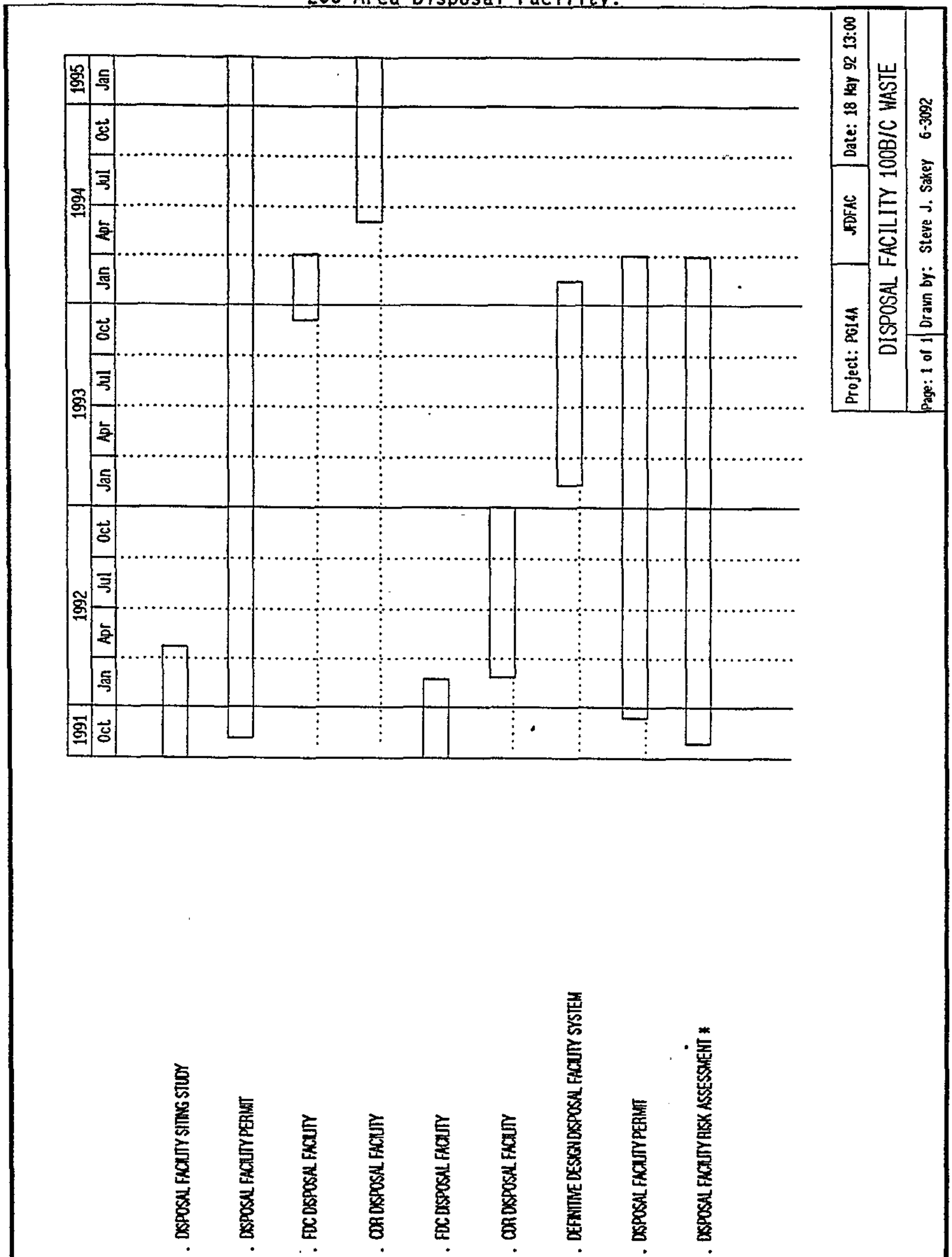

Table 9. Treatability Test.

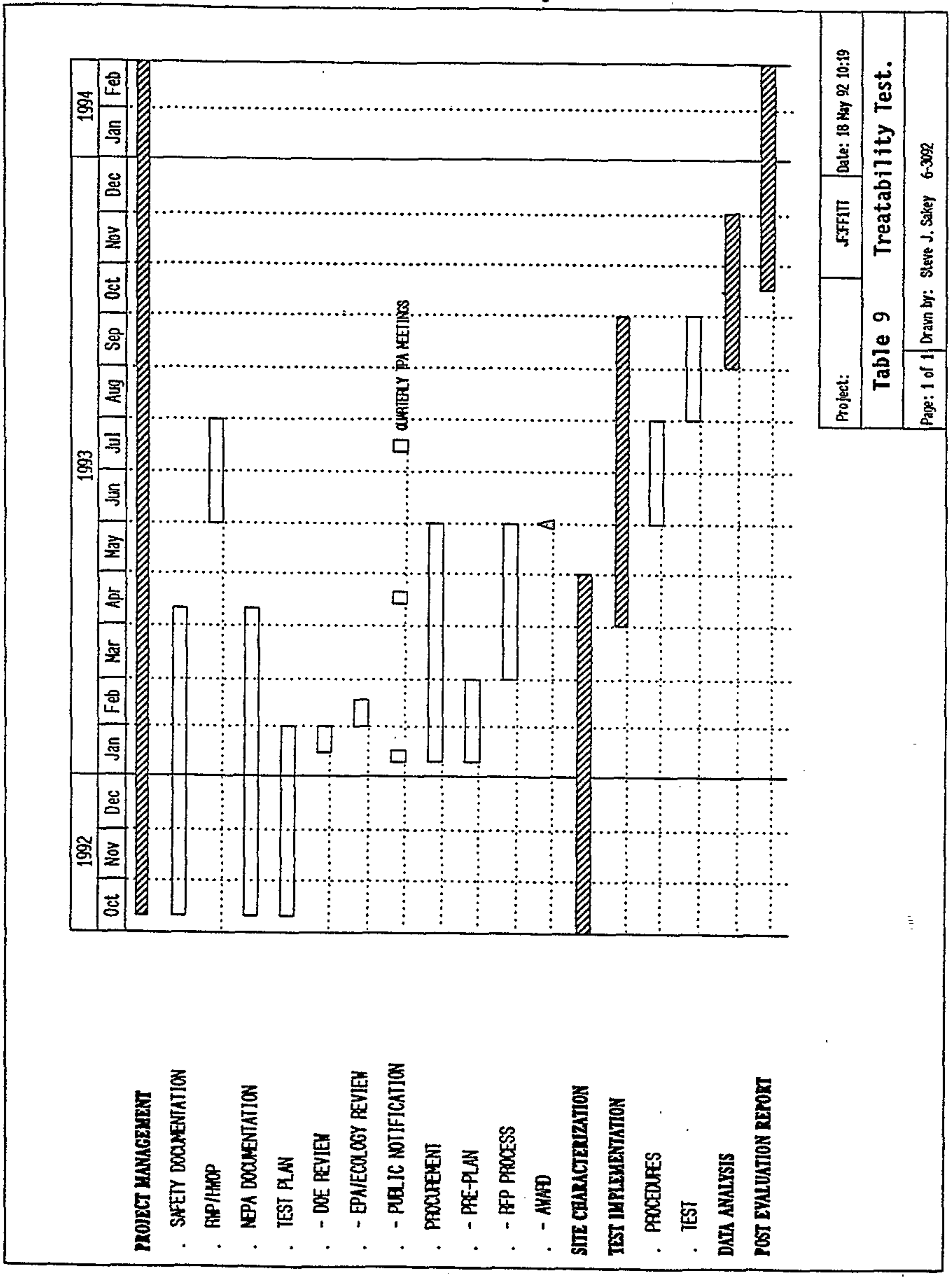

Table 10. Burial Grounds Expedited Response Actions.

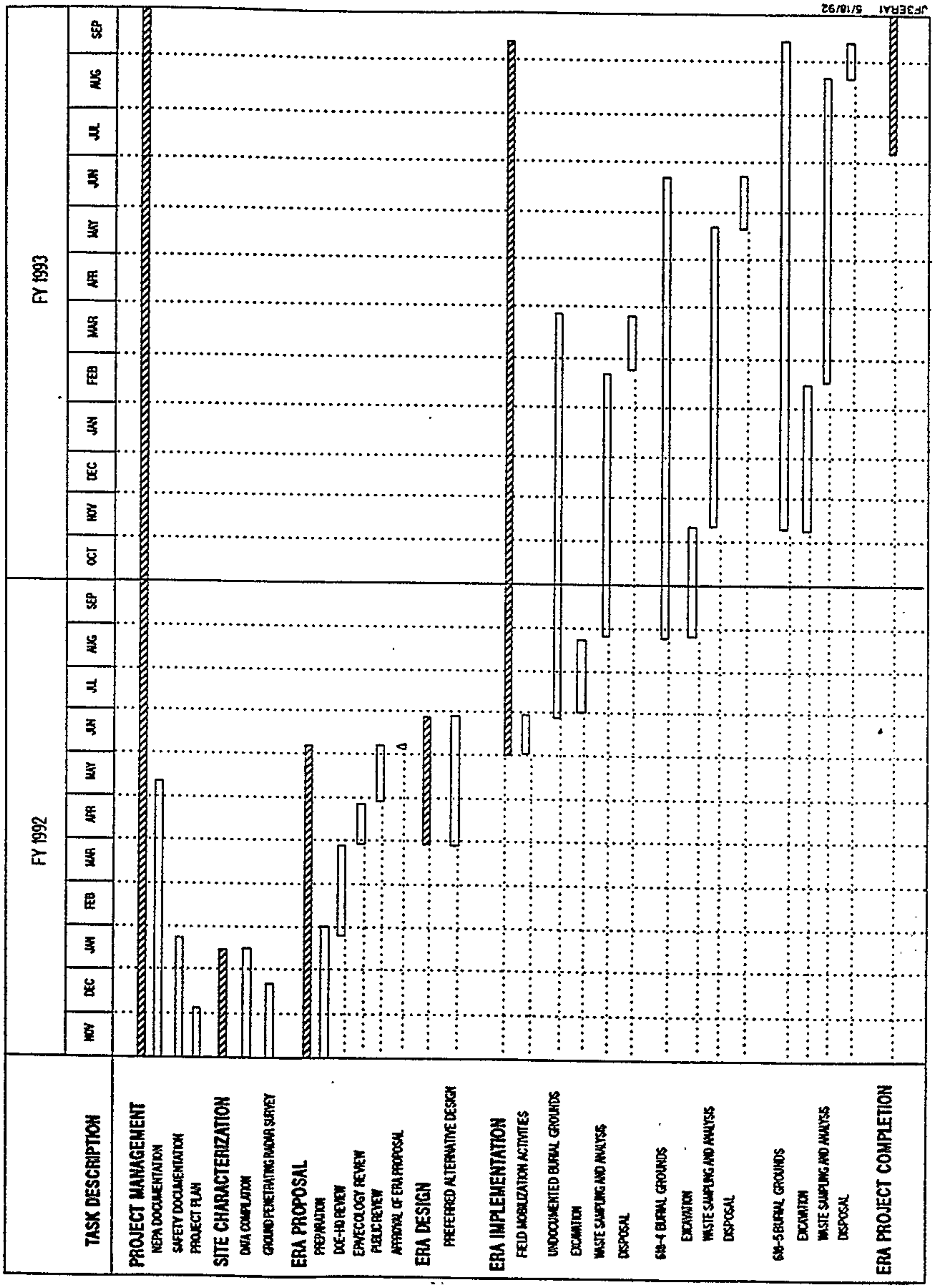

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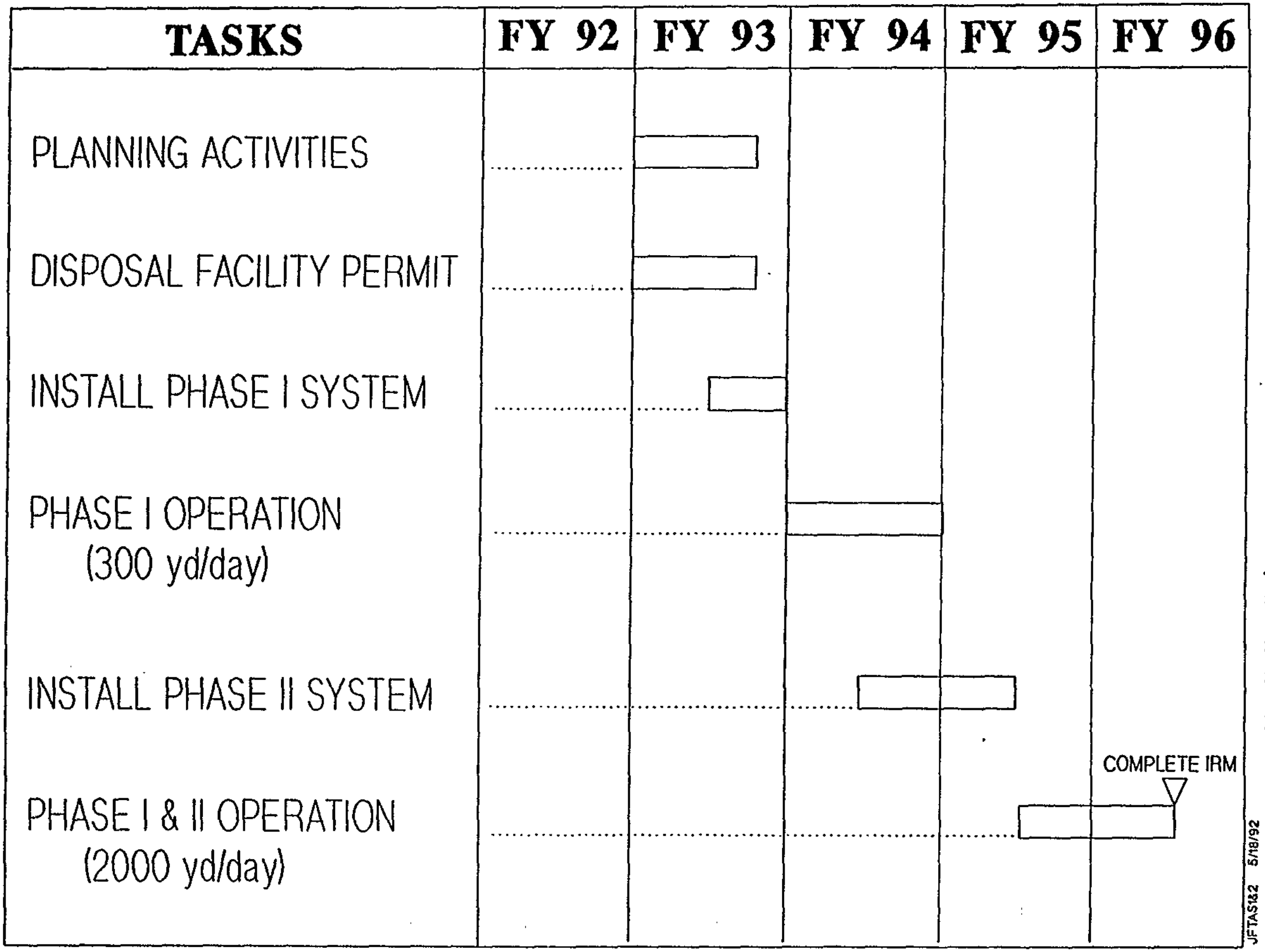
Table 11. 300 Area Interim Response Measure.



The goal of the treatability test is to achieve an 80% to 90% reduction in the volume of contaminated soils based on cleanup target limits in DOE-RL (1992b). It is anticipated that about 600 tons of soil will be processed during the test at a rate of 10 to 20 ton/h. Only nonhazardous chemicals will be used during the test. After testing is completed in the 300 Area, similar testing may be conducted in the 100 and 200 areas. These tests would probably not be conducted until the summer of FY 93 or FY 94.

The IRM is contingent on a successful treatability test. In the IRM 500,000 to 1 M yd^3 of cobbly soil would be excavated and processed through a full scale (100 ton/h) soil separations system. Per negotiated cleanup levels, clean coarse material would be returned to the excavation site. Contaminated materials would be placed in steel containers and transported via flatbed rail cars to the 200 Area.

Part of the IRM may include building two trenches to contain about 100,000 yd^3 of contaminated fine soils. The trenches would need to be completed by December 1994 in order for the IRM to proceed as currently scheduled.

4.3 CARBON TETRACHLORIDE EXPEDITED RESPONSE ACTION

The ERA was initiated at the Hanford Site to remove carbon tetrachloride from contaminated soils in the 200 East Area (Table 12) and to mitigate further contamination of the groundwater.

Preliminary site characterization during 1991 and an engineering evaluation and cost analysis were conducted to evaluate the nature of the contamination and remedial alternatives. The process included a SVE pilot test because preliminary screening of alternatives in the early phase of the project indicated that SVE of the carbon tetrachloride in the unsaturated zone, with some form of aboveground treatment of the soil vapor, would likely be the preferred remedial technology.

The SVE from existing wells is used in the initial remediation phase of the ERA. Treatment of the extracted vapor will consist of using granular activated carbon (GAC) canisters for adsorption of VOC. The GAC will initially be sent offsite to a permitted facility for regeneration and the destruction of carbon tetrachloride. Onsite treatment of GAC is being investigated. Additional vapor extraction units are presently being procured and will begin extraction by Fall 1992.

To enhance the rate and efficiency of removal of carbon tetrachloride from the soils, further study of the well-field design will be conducted. This will include modeling and investigations of well-field enhancement and monitoring technologies. This activity will be integrated with the VOC-Arid ID Site (Appendix B).

9 3 1 2 9 0 0 1 2 5 0

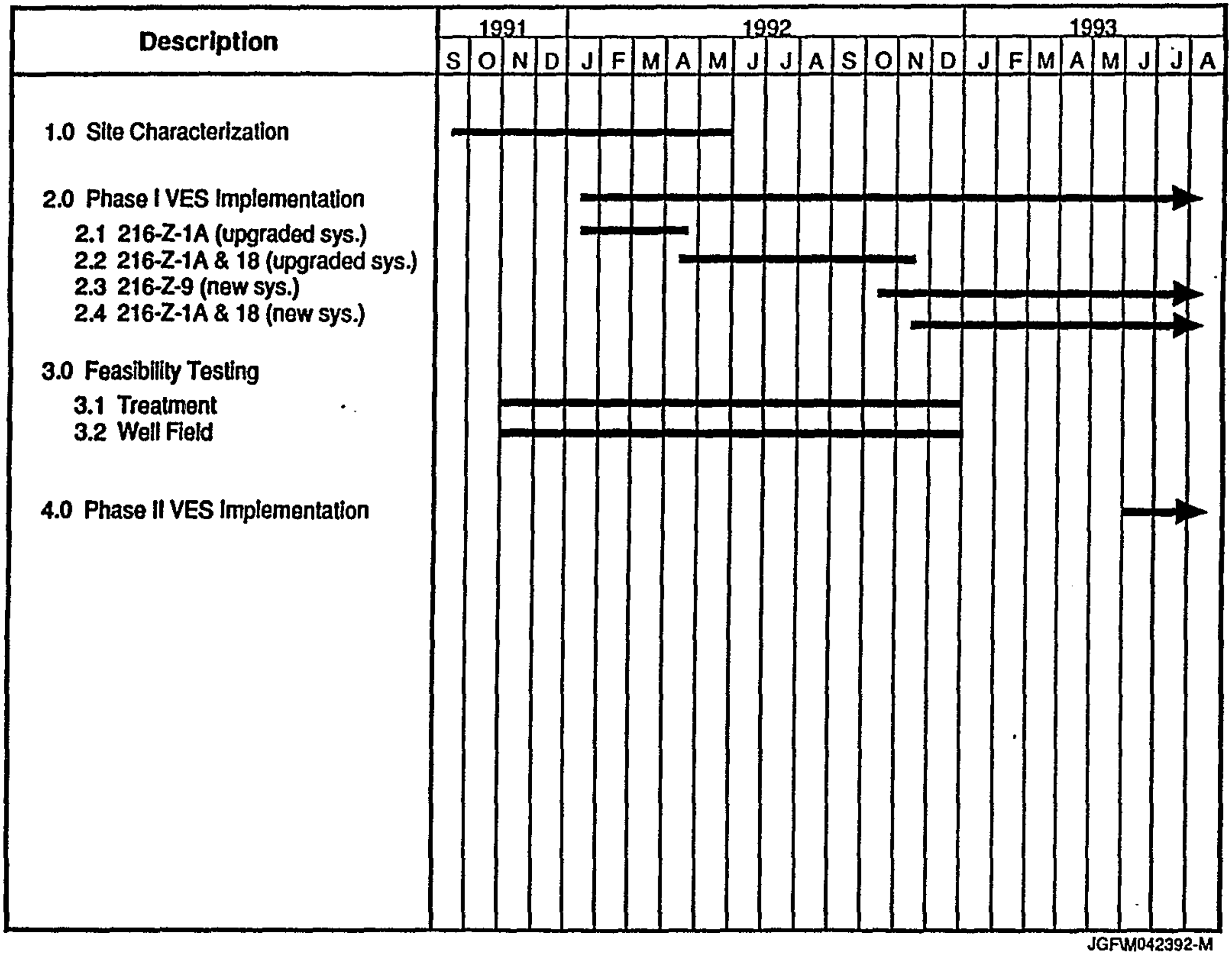


Table 12. Carbon Tetrachloride Expedited Response Action.

4.4 HANFORD SITE BARRIER

The Hanford Site barrier is being developed as a long-term isolation barrier as required for in-situ closure of hazardous and mixed waste sites. The primary function of the barrier is to ensure that potential migration of waste due to precipitation is controlled. The barrier is designed with several layers to enhance moisture storage and evaporation potential, and to minimize potential barrier disturbance due to natural phenomenon, plant, animal, or human intrusion.

Development of the Hanford Site Barrier Project has been underway for many years. Previous bench-scale tests in laboratories and in the Hanford Site lysimeter facilities successfully demonstrated the ability of the barrier to prevent seepage due to precipitation. Extensive studies and modeling have been conducted to assess the potential longevity of the barrier subject to various environmental conditions. Additional testing is needed to demonstrate performance of a full-scale barrier.

The Hanford Site Barrier Project is being conducted by the WHC Engineered Applications Division and PNL with joint funding for FY 92 through EM-50 and EM-40. It is anticipated that all future funding of the Hanford Site Barrier Project will be through EM-40 of the ER Program. A general schedule of activities for the Hanford Site Barrier Program is included (Table 13).

5.0 ASSESSING TECHNOLOGIES

The purpose of this section is to establish a method for the ER Program to assess commercial technologies (specific vendors), to assess technology development proposals, and to identify potential baseline technologies.

The feasibility of vendor specific baseline or potential baseline technologies will be assessed subjectively by WHC Environmental Restoration Engineering (ERE). If determined feasible, ER projects for potential applications of the technologies will be identified. The project leader will conduct further assessments as part of the feasibility study and/or engineering design process.

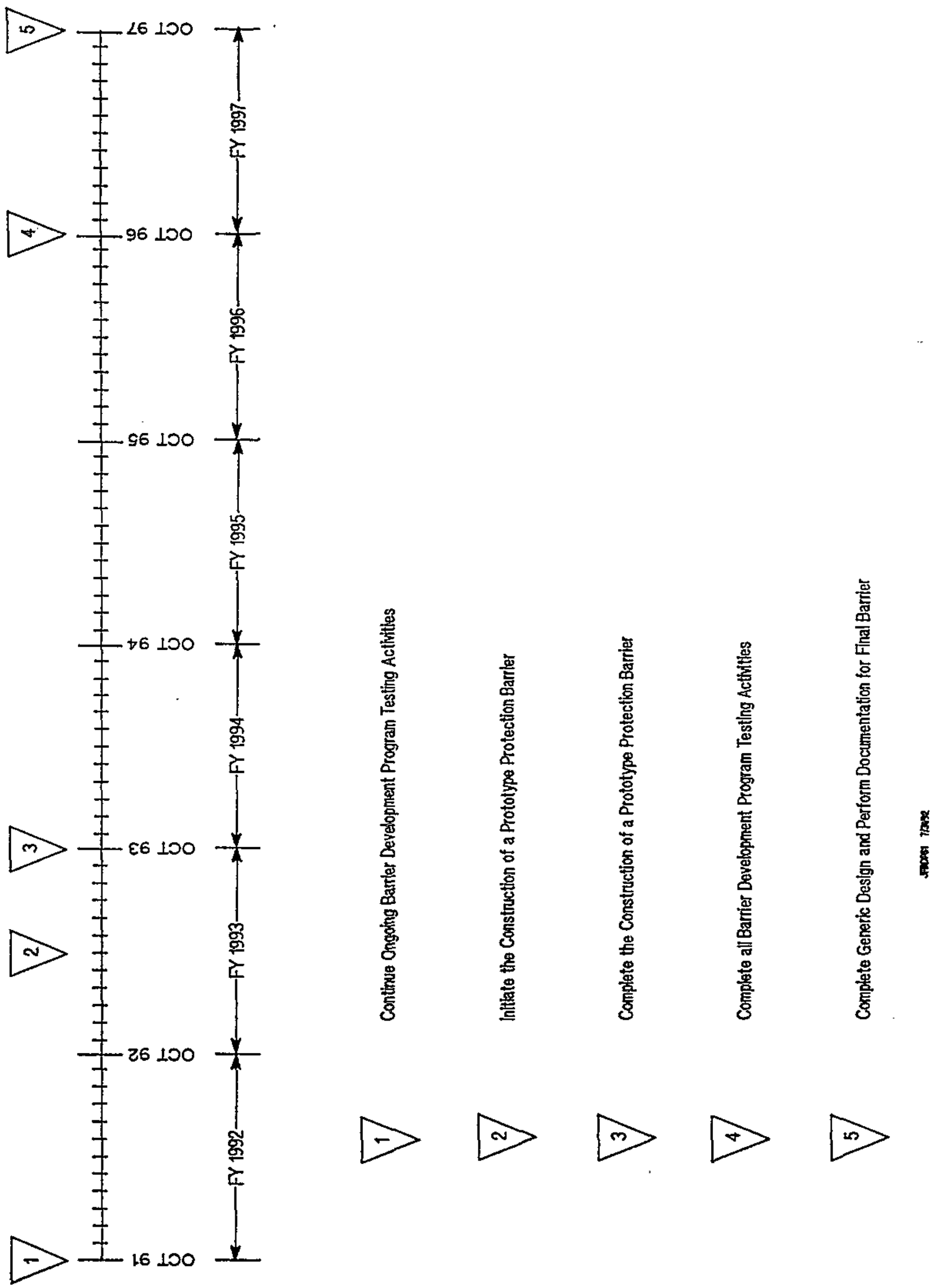
Technologies that are not part of the baseline will be compared with current baseline technologies and evaluated by ERE using the criteria described in this section.

5.1 CRITERIA FOR EVALUATION

All technologies must meet performance parameters when they are established. These include:

- Tri-Party Agreement milestones
- National Environmental Policy Act Documents (NEPA)

Table 13. Schedule for the Hanford Site Barrier Performance Testing.



- Land-use decisions
- Cleanup levels
- Be in line with the overall cleanup strategy.

Until these performance parameters are finalized technologies will be required to meet: Tri-Party Agreement milestones, and the remediation approach described in this document and in macroengineering studies.

Proposed technologies that are not part of the baseline will be compared with current baseline technologies. Only potential performance levels can be evaluated at this stage because little or no testing has been performed to confirm how the technology will perform when implemented in the field. In order of importance, the following criteria will be used:

- Worker and public safety
- Long-term effectiveness and risk minimization
- Environmental impact and regulatory acceptability
- Waste minimization (volume, toxicity, stability)
- Probability of success (ability to meet cleanup levels and schedules)
- Cost savings
- Faster remediation.

As much information as possible should be provided to facilitate an evaluation for each of these criterion.

If a technology proposal (not part of the baseline) does not meet established performance parameters, indicate a potential safety improvement or no change in safety, and indicate improvement over baseline technologies for at least one other criterion; the technology proposal will not be evaluated further and will not be considered for use by the Hanford Site ER Program. Technologies that cannot be ready for field implementation when needed will be further evaluated to assess the benefit of replacing existing technologies after remediation has started and a record of decision has been reached.

Commercially available technologies and proposals that are part of the baseline will be assessed using the same seven criteria, except that a subjective evaluation will be made on a scale of 1 to 10 (10 being the best). More formal evaluations of baseline and potential baseline technologies will be made as part of engineering design activities where the technology may be applied.

5.2 PRIORITIZING PROPOSALS FOR POTENTIAL BASELINE IMPROVEMENTS

Technology development proposals that show a potential improvement over current baseline technologies will be assessed using the criteria outlined in this section. The assessment will be coordinated by an employee within the WHC Environmental Engineering Support Group and will be conducted by personnel within WHC ERE and other technical experts. The priority list will be used as a basis for recommending ER Program needs for technology development activities. As applicable, results of the assessment will be discussed with the vendor or developer.

In the assessment, a scoring matrix will be used in which a score is will be assigned for each of seven evaluation criterion. Scores for each proposal will be assigned as follows:

$$\text{Total score} = S_A W_A + S_B W_B + S_C W_C + S_D W_D + S_E W_E + S_F W_F + S_G W_G$$

Where: S = Raw Score
W = Weighting factor for criterion

$_A$ = Potential worker and public safety

$_B$ = Potential long term effectiveness and risk minimization

$_C$ = Potential environmental impact

$_D$ = Potential for waste minimization

$_E$ = Probability of success

$_F$ = Potential cost savings

$_G$ = Potential for faster remediation

The assessment will be documented in a "vendor file" and data base maintained by WHC ERE and will be used by the WHC ER Program Office as a guide for establishing Hanford ER Program funding priorities for technology applications and development activities. A score of "150" will be arbitrarily selected as a guide point to evaluate whether a technology should be considered further. Scores for all potential baseline remediation technologies identified in this document were higher than 150 (Appendix C).

5.2.1 Criteria Weighting

The relative importance (weight) for each criterion was evaluated by managers, scientists, and engineers within WHC ERE. Each evaluator filled in the matrix shown in Figure 3 by assigning a letter to each box to show which of two criterion were most important. The letter was followed by a number between 1 and 4 to indicate a major preference (4), medium preference (3), minor preference (2), or no preference (1). Scores for each (criterion) were added to determine the weighting for that criterion.

Table 14 shows the mean weight and standard deviations for each of the criterion. There was a high degree of variability in which criteria were considered most important. However, even considering variability, mean scores reflect the overall order of importance for the selected criteria, and results of similar weighting criteria for the Hanford Mission Plan (DOE/RL 1991). Therefore, the mean values will be used as weighting factors for each criterion.

Figure 3. Matrix to Assess the Relative Importance (weight) of Evaluation Criteria.

4 = Major preference
3 = Medium preference
2 = Minor preference
1 = No preference

Assign a letter to each box to indicate preference and a number to show how much preference. A score of 1 is assigned to both letters being compared.

Add all numbers for a letter to determine total scores for that letter.

	B	C	D	E	F	G
A						
	B					
		C				
			D			
				E		
					F	

Table 14. Individual Scores, Mean, and Standard Deviation Showing Relative Importance (weight) Assigned to Evaluation Criteria.

Safety	Effectiveness	Environmental impact	Waste minimization	Success	Cost	Faster
A	B	C	D	E	F	G
20	13	16	8	6	2	0
19	16	8	8	9	3	0
12	16	7	11	2	4	0
21	5	3	12	6	2	10
23	6	11	0	8	2	9
22	17	15	2	4	7	1
7	14	9	10	4	3	0
24	18	13	2	3	4	6
16	11	6	16	1	4	2
16	11	11	15	3	10	3
mean 18.0	12.7	9.9	8.4	4.6	4.1	3.1
std 5.1	4.2	3.9	5.3	2.5	2.4	3.7

5.2.2 Criterion Descriptions and Scoring

5.2.2.1 Worker and Public Safety. This criterion was assigned the highest weighting (18). It includes both as low as reasonably achievable (ALARA) safety considerations and industrial safety. This is consistent with the DOE philosophy of placing safety as a top priority in all environmental cleanup operations, and the WHC Motto "Safety in everything we do." While safety is assigned the greatest importance for prioritizing technology proposals, it should be understood that this refers to situations where safety (i.e., protection of life and health) is a real concern. It does not refer to measures or technologies to eliminate or minimize risks or exposure levels that are not a health concern.

A score of 10 will be assigned for a technology with a potential for 1/10th risk or less compared to the baseline; 0, if there is no discernable difference; and -10 if the risk is 10 times greater than that for the baseline. As for many of the criteria, these scores are subjective and will be based on the judgement of evaluators. Scores between -10 and 10 are assigned proportionally to the potential safety risk.

5.2.2.2 Long-Term Effectiveness. Long-term effectiveness was given the next highest weighting (12.7). It considers the permanence of remediation that would be achieved by a proposed technology. Long-term effectiveness considers risk minimization, future cleanup needs, long-term operation, maintenance and monitoring requirements, and the ability of the technology to meet applicable or relevant and appropriate requirements (ARAR).

A score of 10 will be assigned to technologies that show a potential to be greater than or equal to 10 times more effective; 0 for no change in effectiveness compared to the baseline; and -10 for technologies more than 10 times less effective than the baseline.

5.2.2.3 Environmental Impact. Environmental impact refers to potential ecological impacts to the environment and also considers the probability of regulatory and public acceptability of the proposed technology. This criterion was assigned a weighting factor of 9.9.

As for waste minimization, a score of 10 is assigned for technologies with a potential of 10 times less environmental impact and 10 times greater probability of acceptance compared to the baseline; 0 for the same; and -10 for technologies with a potential for more than 10 times greater environmental impact or less than 1/10th chance of regulatory acceptance.

5.2.2.4 Waste Minimization. This criterion (weighting factor, 8.4) compares applicable baseline technology elements with proposed technologies for waste minimization by volume reduction, toxicity reduction, and/or stabilization. Projected secondary waste volumes associated with technology operations are subtracted from the waste minimization volume.

If waste minimization volumes are more than 10 times greater than that for baseline elements a score of 10 is assigned. A -10 is assigned if the volume of waste minimized is over 10 times less than the baseline.

5.2.2.5 Certainty of Success. This is a measure of the probability that a technology will perform as it is expected to (weighting factor, 4.6). The highest confidence would be placed in a technology that has been successfully tested and/or used offsite in similar applications. Similarly in most cases, less confidence would be placed in a technology that has not been tested. Scores will be assigned as follows:

• No development needed	10
• Applied offsite	8
• Pilot tested offsite	6
• Laboratory tested onsite	4
• Laboratory tested offsite	3
• Theory only	2
• No basis for technology	0

5.2.2.6 Cost. Costs shall include, as applicable, development, capital, operation and maintenance, and monitoring costs related to a selected technology. This shall be a rough order of magnitude cost compared with a baseline element on an equal basis (e.g., present value or annual cost estimates).

Scores shall be proportional to the relative cost increase or decrease as compared to baseline elements. For example, a technology that would cost 1/100th or 100 times less than baseline costs would be given a score of 100. If costs for the proposed technologies are higher than the baseline cost a proportionally negative value shall be assigned.

While cost was determined to be a less significant factor (weight 4.1) compared to other criteria, this approach gives a higher score to technologies that show a potential for substantial cost savings and serves as a screening method for costs that are unreasonably high.

5.2.2.7 Faster Remediation. This criterion refers to technologies that provide a faster treatment (or investigation capacity) than baseline elements. However, all technologies considered must meet Tri-Party Agreement milestones, therefore, this criterion was assigned a low weighting factor (3.1).

Scores shall be assigned, up to a maximum of 10 and minimum -10, in proportion to the relative speed of a technology proposal compared to baseline elements.

6.0 CRITERIA TO IMPLEMENT TECHNOLOGY IMPROVEMENTS TO THE BASELINE

Prior to incorporating a new technology, and modifying or changing the baseline, the technology must be tested at a pilot or full-scale level. After these tests are completed and technology performance is verified, the technology will again be compared with the baseline using the criteria discussed in Section 5.0.

If the technology is safer or as safe as the baseline technologies being compared, shows a potential improvement over baseline technologies (as determined by the scoring system defined in this document, and approval by ER Program Management), can meet technology transfer requirements in a timely manner, and is in-line with the overall cleanup strategy for Hanford past-practice sites, it will be implemented.

7.0 TECHNOLOGY TRANSFER REQUIREMENTS

Technology transfer requirements include the following developments, which must be completed prior to accepting the technology:

- Documented testing of performance, treatability tests require at least a Level III QA Analysis of system performance (EPA 1989)
- Completing operating manuals and procedures for the technology
- Training of site personnel, if required, to operate the equipment/technique
- Environmental and health impacts of technology selections must be bounded by criteria that will be presented in the HRA-EIS (this criteria will only apply after the HRA-EIS is approved by DOE and the EPA)
- Regulatory acceptance of the technology
- Possession of appropriate equipment and regulatory operating permits as applicable.

Design specifications for technologies and an adequate supply of equipment or systems must be available for intended applications. Government contract procurement procedures must be followed to test and implement technologies used at the Hanford Site.

8.0 REFERENCES

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APPENDIX A

HANFORD ENVIRONMENTAL RESTORATION TECHNOLOGY BASELINE SELECTION

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CONTENTS

APPENDICES

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1.0 PANEL DISCUSSION

A panel discussion was held with WHC, IT Corporation, and EBASCO Corporation personnel to discuss and select technology baseline elements for the 100-B/C demonstration and Hanford Site-wide remediation.

A brief introduction provided an overview of the macroengineering effort to date and to outline plans for future efforts at the 100-B/C Area and site-wide. After some discussion, the meeting scope was defined as follows:

- Select a technology baseline for the 100-B/C Area; i.e., what technologies and approaches would be used that make sense and can be implemented in the near-term. In addition, the screening process should identify those technologies which, while not part of the initial baseline because they are not proven, would potentially become part of the baseline when further development shows them to be viable. Technologies in this classification are identified as 'potential baseline.'

- Select a technology baseline for the Hanford Site-wide restoration program. Consider only available technologies that are implementable over the long term, meet remedial objectives, and provide a baseline for which technology alternatives can be evaluated.

A list of technology options from the macroengineering studies was compiled to provide a basis for discussion and selection. The listing is given in Appendix A.1.

Evaluation criteria were proposed and discussed. The final listing is given in Appendix A.2. It was generally agreed that commercial availability would be the most important criteria for the 100-B/C baseline because the short time-frame for implementation would not likely allow time for significant engineering or technology development.

Technology options shown in Appendix A.1 were discussed by the panel. Initially there were several differences in the baseline for the 100-B/C demonstration and site-wide. However, after further comparison and review, it was determined that a single remediation baseline and 'potential baseline' could be established that is applicable to both the 100-B/C demonstration, and site-wide technology needs. The resulting technology selections are summarized in Appendix A.3. Additional discussion of rationale is given in the following sections.

Formal comments and additional discussions with WHC managers and other technical contributors helped to refine a remediation baseline. Results of comments, meeting discussions, and proposed changes in the macroengineering approach are reflected in Appendix A.3.

2.0 RATIONALE FOR BASELINE SELECTIONS

This section provides a general overview of the rationale used in arriving at a consensus regarding the baseline selections.

2.1 WASTE SITE CHARACTERIZATION

The panel agreed that extensive pre-remediation characterization was not necessary to implement macroengineering since concurrent characterization would be the most cost-effective way to establish extent of contamination.

- Geophysical techniques do not work very well and would likely not give information that would alter the site excavation approach. It was agreed that geophysics could be useful in the 200 Area for delineating burial grounds that would be in-situ stabilized.
- Surface radiation surveys are deleted from the baseline; these are done routinely at the Hanford Site and additional surveys would not be cost effective.
- Intrusive soil sampling is expensive and not worth the information gained; i.e., excavation with concurrent characterization is the better approach.
- Drum radiography is redundant since intact drums would have to be opened anyway. Boxes would be compacted and would not need prior inspection.
- Soil-gas surveys would be limited to only those areas that were expected to contain large quantities of VOC.

2.2 SITE CONTAINMENT/DUST CONTROL

- Water sprays would be the main form of stabilizing soils for dust control. Acceptance of dust suppressants such as fixants, binders, encapsulants and polymers is subject to testing and/or development to prove effectiveness. Therefore, these are included as 'potential baseline.'
- Wind skirting is unproven and not likely to work at the Hanford Site.
- Mobile bridge-truss structures are not available, and further investigations show that they are probably not needed at the Hanford Site. Frame-supported, negative pressure tents should be used if structural containment is required by safety assessments. Value engineering studies have indicated that structural containment is not necessary for most sites.

2.3 WASTE REMOVAL/OBJECT SIZE REDUCTION

- Scrapers should be used instead of a pavement profiler for the 200 Area shallow sites; these would not require pre-removal of plants and would work better in cobbly soils. However, the pavement profiler is retained as 'potential baseline' since it potentially offers better dust control. The profiler would also have potential application as a primary excavation device since it could be used to excavate deeper contamination in 'lifts.' Equipment development/ modification would be required to prove the pavement profiler for use in the Hanford Site cobbly soils.

- Mechanical cutting is favored over torches since it is faster and does not vaporize contaminants.

- In-container soil venting is deleted from the baseline in favor of thermal desorption; soil venting will not handle semivolitile organic compounds (SVOC) but thermal desorption will, which is much faster.

2.4 SPECIAL ITEMS/ENGINEERED MODIFICATIONS

While technology is not yet ready for remote controlled excavation equipment, this should be a high priority item for development as it could be beneficial for high hazard sites. Remote excavation technology is retained as 'potential baseline.'

2.5 WASTE PROCESSING/VOLUME REDUCTION

- Soil washing will not be part of the baseline but will be retained as 'potential baseline;' the technology holds promise but has not yet been proven for Hanford Site contaminants; treatability testing in the 300 Area is planned.

- Shredding of combustibles is judged impractical; very careful sorting or expensive separation systems would be required to remove soil cobbles that could destroy a shredder.

- Concrete crushers were not selected for the baseline; mobile processors will achieve adequate concrete size reduction since soil washing was deleted from the baseline.

- Pipe shredding was canceled since washing was eliminated; pipe compaction is the favored option; large pipes would be size reduced by compacting, using rams or devices similar to a 'car crusher.'

- Drummed waste (intact drums only) would be handled by:

  - open/inspect
  - sort contents
  - pump out liquids, if any,
  - solidify nonorganic liquids

- send solids and liquids contaminated with organics to a thermal desorber system
- send solids not contaminated with organics to a supercompactor

- Mobile incinerators would be difficult to control with solid waste that varies in composition; a thermal desorber system is a better option. The thermal desorber system would consist of two stages; a low temperature desorber for solids, and an incinerator off-gas system to handle off-gas and combustible liquids.

2.6 WASTE CONTAINERS/TRANSPORTATION

- Steel boxes will be the baseline container (shipped in reusable overpacks); the optimum size of the box will be determined in design studies.

- Rail hopper cars were eliminated from the baseline; these would be more difficult than boxes to decontaminate; since boxes are needed for solid waste anyway, it is not desirable to have a second system for soils.

- Slurry pipelines will not be required since soil washing was eliminated.

2.7 SITE RESTORATION

Recontouring is preferred over full reclamation; full reclamation would add cost to haul in large volumes of soil; there may be no environmental benefit from full reclamation.

2.8 WASTE SITE REMEDIATION - 200 AREA HIGH ACTIVITY SITES

Testing is needed to demonstrate that dynamic compaction and vibration-aided grouting are effective in minimizing/eliminating subsidence potential.

2.9 WASTE DISPOSAL: 200 AREA

- ISV (for compactible waste stabilization) is included as 'potential baseline' only, since it is not yet proven; continue development.

- Ex-situ vitrification (for compactible waste stabilization) using incinerator/melter technology is included as 'potential baseline' pending technology development and feasibility studies.

- Concrete 'honeycomb' structures within the compactible waste sites will be the baseline for subsidence prevention. This will need engineering, but not technology development, and cost trade-off studies to evaluate against ex-situ vitrification and ISV.

- Disposal trenches for low activity bulk and packaged wastes will be single-lined for the 100-B/C demonstration, but unlined for site-wide applications. Linings are not durable over the long term. The 100-B/C demonstration should show that the isolation barrier provides adequate protection.

2.10 GROUNDWATER REMEDIATION

This scenario would include monitoring and institutional controls in perpetuity. Source removal/stabilization is an integral part of this scenario, since this would effectively eliminate contaminant transport from soils to groundwater. The panel agreed that additional cost/benefit studies would be needed to make a case for this scenario relative to the other scenarios that involve pump/treat and/or aquifer mining. This scenario meets remedial objectives, since there is no current risk as a result of groundwater contamination and no future risk as long as institutional controls are in place (required for an extended period even if active remediation were employed).

The lack of available cost-effective remedial approaches to groundwater cleanup underscores the need for development of workable and cost effective in-situ techniques such as chemical injection and bioremediation.

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APPENDIX A.1

MACROENGINEERING TECHNOLOGY ALTERNATIVES
(COMPILATION FROM CONCEPTUAL STUDY REPORTS, WHC 1991)

WASTE SITE REMEDIATION:
100/300/200 AREAS LOW ACTIVITY

WASTE SITE CHARACTERIZATION

Pre-Excavation:
- Historical Data Review
- Soil-Gas Survey (VOC in soils/burial grounds)
- Geophysical Investigations (burial grounds)
  - Ground-penetrating Radar
  - Electromagnetic Induction
  - Magnetometry
  - Passive Metal Detector
  - Driven Electrode Conductance
  - Cone Penetrometer
- Surface Radiation Survey
- Strategic Soil Sampling
  - Drilled Borehole
  - Trowel/Hand Auger
  - Backhoe

Field Instrumentation:
- Truck Mounted Detectors
  - Geiger-Mueller for rads
  - Portable gas chromatograph for VOC
  - Criticality (neutron) Monitors
- Conveyor Mounted Detectors
  - Geiger-Mueller for rad
- Radiography (drums and boxes)
- Hand-held (rad/VOC/metals)
  - Geiger-Mueller
  - Alpha Detector/Fiddler
  - Neutron Assay
  - Portable Gas Chromatograph
  - O2/Explosivity Meters/Monitors
  - Photo-ionization/flame-ionization detectors
  - Portable XRF
  - Soil Conductivity
  - Draeger Tubes

Field Sampling:
- Conveyor auto-sampler
- Manual grab samples

Post Excavation Site Certification:
- Soil coring

Analytical:
- Mobile Labs
  - Alpha/Beta/Gamma Counting
  - XRF
  - Ion Selective Electrode
  - Gas chromatograph mass spectroscopy
  - Supercritical Fluid Extraction
  - Wet Chemical
- Fixed Labs
  - Standard Methods (with full QA/QC)

SITE CONTAINMENT/DUST CONTROL

Dust Control:
- Water sprays
  - Fixed Sprinklers
  - Water Trucks
- Dust Suppressants/Fixants
  - Gunite
  - Binders (e.g. tree-sap, asphalt)
  - Encapsulants
  - Surfactants

Containment Structures:
- Wind Skirting (low risk sites)
- Tents (small/narrow sites)
  - Frame-supported
  - Parallel-arch
- Mobile Bridge-truss Structures (large sites)
- Sheet Piling (river pipelines)

WASTE REMOVAL/OBJECT CUTTING

Excavation: Land
- Loaders
- Dozers
- Backhoes
- Scrapers
- Pavement Profiler (shallow sites)
- Dump Trucks

Excavation: River
- Clamshell Dredge

Object Cutting/Size Reduction:
- Universal Processors w/Attachments
- Cutting Torches
  - Boom-mounted
  - Underwater
  - Hand-held

VOC Removal:
- In-situ Soil Venting
- In-container Venting
- VOC Vapor Incineration

SPECIAL ITEMS/ENGINEERED MODIFICATIONS

Remote Controlled Excavators
Cab Shielding
Self-contained Air Supply

WASTE PROCESSING/VOLUME REDUCTION

Soils Volume Reduction:
- Wet Screening
- Gravel Washing (10-50 mm)
- Attrition Scrubbing/Acid Wash (0.125-10 mm)
- Clarifier/Vacuum Filter (-0.125 mm)

Solids Volume Reduction:
- Combustibles
  - Shredding
  - Supercompaction
- Concrete/Clay/Glass
  - Crushing
  - Soil Washing (non-SVOC)
  - Thermal Desorption/Rotary Kiln (SVOC)
- Piping/Metals
  - Shredding
  - Soil Washing (non-SVOC)
  - Thermal Desorption/Rotary Kiln (SVOC)
  - Supercompaction
- Drummed Waste
  - Sorting
  - Shredding/Supercompaction (combustibles/metals)
  - Repackaging/Incineration (organics)

Organic Waste Processing:
- Thermal Desorption/Rotary Kiln (solid waste/SVOC)
- Mobile Incineration (drummed waste)

Washwater Treatment:
- Clarifier/Sand Filter
- Reverse Osmosis
- Selective Liquid Membrane
- Evaporation
- Dewatering Pond

WASTE CONTAINERS/TRANSPORTATION

Containers:
- Steel 50 yd^3 (reusable) w/reusable overpack
- Steel 50 yd^3 (single Use) w/reusable overpack
- Steel 12 yd^3 (grouted single use)
- Steel 24 yd^3 (supercompacted single use)
- Steel 5 yd^3 (reusable)
- Steel Caissons
- Pipe Racks w/plastic covers
- Plant Bales w/plastic covers
- Drum Overpacks

Rail Hopper Cars

Local Transport:
- Dump Trucks
- Belt Conveyors (soils)
- Slurry Pipelines (soils)
- Barges (river pipelines)
- Gantry Cranes
- Bridge Cranes
- Forklifts
- Pneumatic Pickers

200 Area Transport:
- Rail Hopper Cars (bulk soils)
- Rail Flat Cars (containers/pipe racks)

SITE RESTORATION:

- Full Reclamation
- Recontouring
- Revegetation

WASTE SITE REMEDIATION: 200 AREA HIGH ACTIVITY

In-Situ Stabilization:
- Dynamic Compaction
- Vibration-aided Injection Grouting

Site Closure:
- Permanent Isolation Barrier (Hanford Barrier)

WASTE DISPOSAL: 200 AREA

Bulk Waste Unloading:
- Bridge Cranes
- Rail Car Inverters
- Containment Building

Packaged Waste Unloading:
- Boom Cranes
- Fork Lifts
- Trucks

Bulk Waste Disposal Facility: Low Activity Bulk Wastes
- Trench (unlined or single membrane liner)
- Containment Building

Packaged Waste Disposal Facility: Low Activity Packaged Wastes
- Unlined Trench

High Activity Waste Disposal Facility:
- Reinforced Concrete Vaults

Slurry Dewatering Ponds:
- Clay/membrane Double Liner
- Collection Sumps
- Vacuum Assisted Dewatering
- Floating Cover

Site Closure:
- Dynamic Compaction
- Vibration Aided Grouting
- In-Situ Vitrification (compactable wastes only)
- Sand Backfill
- Permanent Isolation Barrier (Hanford Barrier)

Long Term Monitoring:
- Motion detectors
- Physical Sensors
- Television
- Subsidence Monitoring (lasers)
- Well Sampling/Monitoring

GROUNDWATER REMEDIATION:

NO ACTION

Monitoring (in perpetuity)
Institutional Controls (in perpetuity)

SCENARIO 1

Monitoring (all groundwater in perpetuity)
Institutional Controls (all groundwater in perpetuity)

Site Investigation:
- Pump testing
- Injection testing
- Sampling/analysis

Groundwater Extraction:
- Wells (100/300/600 areas)
- None (200 Area)

Groundwater Treatment:
- None

Groundwater Injection:
- Wells - Centralized Location

Waste Transport:
- Double-Pipe in Lined Trenches
- Leak Detection Sumps

SCENARIO 2

Monitoring (all groundwater during remediation only, 200 Area in perpetuity)
Institutional Controls (same as monitoring)

Site Investigation:
- Pump Testing
- Injection Testing
- Sampling/Analysis
- Lithology Sampling
- Geophysical Surveys

Groundwater Extraction:
- Wells (100/300/600/200 areas)

Groundwater Treatment:
- Clarifier/Sand Filter
- Reverse Osmosis
- Selective Liquid Membrane
- Ion Exchange
- Iron Coagulation
- Evaporation
- Biological Denitrification
- Enhanced Oxidation

Groundwater Injection:
- Tritiated Treated Water - Centralized Location

Clean Water Diversion:
- Deep Slurry Cutoff Walls
- Horizontal Wells
- Pumping/Energy Recovery/River Discharge

Waste Transport:
- Double-Pipe in Lined Trenches (untreated, treated/tritiated Water)
- Buried Single Wall Pipe (treated non-tritiated water, clean water)
- Leak Detection Sumps

SCENARIO 3

Monitoring (all groundwater during remediation, 200 Area in perpetuity)
Institutional Controls (same as monitoring)

Site Investigation:
- Pump Testing
- Sampling/Analysis
- Lithology Sampling
- Geophysical Surveys

Groundwater Extraction:
- Wells (100/300/600/200 areas)
- Lixiviant-Enhanced Dissolution
  - Contaminant Specific Lixiviants
  - Injection Wells

- Aquifer Mining
  - Shovel/Truck (overburden)
  - Suction Dredges
  - Slurry Transport

Groundwater Treatment:

- Clarifier/Sand Filter
- Reverse Osmosis
- Selective Liquid Membrane
- Ion Exchange
- Iron Coagulation
- Evaporation
- Biological Denitrification
- Enhanced Oxidation
- Sediment Washing
  - Wet Screening
  - Vacuum Filter Dewatering
- Tritium Separation (heavy water plant)

Groundwater Disposal:

- Columbia River Discharge

Clean Water Diversion:

- Deep Slurry Cutoff Walls
  - Hydraulic Excavating Machine
  - Wide Trench
- Horizontal Wells
- Pumping/Energy Recovery/River Discharge

Waste Transport:

- Double-Pipe in Lined Trenches (untreated, treated/tritiated water)
- Buried Single Wall Pipe (treated non-tritiated water, clean water)
- Leak Detection Sumps
- Bulk Rail Hopper Cars (mined sediment fines)

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APPENDIX A.2

MACROENGINEERING BASELINE TECHNOLOGY SELECTION

EVALUATION CRITERIA AND OBJECTIVES

Criteria	Must/ want	Objectives
Commercial availability	Must	Proven in similar applications
Effectiveness	Must	Meets cleanup goals
Cost/benefit ratio	Want	As low as possible
Safety	Must	Minimal risk/meets ALARA
Development needs (treatability testing on pilot or full scale)	Want	Minimal
Engineering design needs	Want	Straightforward
Reliability	Want	High
Schedule/implementability	Must	Meets requirements
Capital investment	Want	Moderate
Regulatory acceptability	Must	High probability
Public acceptability	Want	High probability

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APPENDIX A.3

HANFORD BASELINE TECHNOLOGY SCREENING

Technology	Baseline	Potential baseline	Comments
WASTE SITE CHARACTERIZATION Pre-Excavation Historical data review	Yes		
Soil-gas survey	Yes		Only used where VOC are suspected
Geophysical investigations	Yes		For in-situ stabilization of burial grounds (200 Area); indicates rough outline of waste site
Surface radiation survey	No	No	Does not tell much. Does not change excavation method
Strategic soil sampling	Yes		Use only for 200 Area liquid waste sites closed in-situ
Sample river sediment and river pipelines	Yes		Characterization is cost effective; potentially avoids coffer dam construction
Field Instrumentation Vehicle mounted detectors	Yes		
Conveyor mounted detectors	Yes		
Radiography (drums and boxes)	No	No	Intact drums will be opened; non-intact drums/boxes will be compacted
Hand-held (rad/VOC/metals)	Yes		Limited use in low radiation areas

Technology	Baseline	Potential baseline	Comments
Field Sampling Conveyor auto-sampler	Yes		
Manual grab samples	Yes		
Post Excavation Site Certification Soil coring	Yes		
Analytical Mobile labs	Yes		Development issue: mobile labs must be able to perform radioactive screening analysis.
Fixed labs Standard methods (w/full QA/QC)	Yes		
SITE CONTAINMENT/DUST CONTROL Dust Control Water sprays	Yes		
Dust suppressants fixants, binders, encapsulants, polymers	No	Yes	Development issue; test to see if effective
Containment Structures Wind skirting (low risk sites)	No	No	Not effective, especially in Hanford winds
Tents (negative pressure)	Yes		Only will be used if required for safety
Mobile bridge-truss structure (large sites)	No	No	Not developed; probably not needed at Hanford Site
Sheet piling (river pipelines)	Yes		

Technology	Baseline	Potential baseline	Comments
WASTE REMOVAL/OBJECT SIZE REDUCTION Excavation: Land Loaders, dozers, backhoes, scrapers, trucks, etc.	Yes		
Excavation: River Clamshell dredge	Yes		
Object Cutting/Size Reduction Universal processors w/attachments	Yes		
Cutting torches boom mounted	No	No	Can volatilize radionuclides; universal processors should handle most situations
Underwater	Yes		Use for river pipelines
Hand-held (land use)	No	No	Personnel exposure problem
VOC Removal In-situ soil venting system	Yes		Used for VOC, if at significant levels (determined by soil-gas survey)
In-container venting	No	No	Expect small volumes; use thermal desorber system for VOC/SVOC contaminants
Thermal desorber system	Yes		The system includes two stages a low temperature thermal desorber for solids, and an off-gas incinerator for combustible liquids off-gases
SPECIAL ITEMS/ENGINEERED MODIFICATIONS Remote controlled excavators	No	Yes	High priority for further investigation; equipment is available, but may not be required for most sites

Technology	Baseline	Potential baseline	Comments
Cab shielding	Yes		
Self-contained air supply (for excavation equipment)	Yes		
WASTE PROCESSING/VOLUME REDUCTION Solids Volume Reduction/Processing Soils Soil washing and wash water treatment	No	Yes	Soil washing not proven for Hanford application; needs testing
Solidification/ stabilization	Yes		If required to meet land ban requirements
Thermal desorber system	Yes		To remove VOC/SVOC
Combustibles Shredding	No	No	Not practical; stones will destroy shredder
Supercompaction	Yes		
Concrete/clay/glass crushing	No	Yes	Mobile processors will achieve adequate size reduction
Solidification/ stabilization	Yes		If required to meet land disposal restrictions
Thermal desorber system for VOC/SVOC	No	Yes	Would require crushing
Piping/Metals Shredding	No	Yes	Use compactor for pipe
Solidification/ stabilization	Yes		If required to meet land disposal restrictions
Thermal desorber system for VOC/SVOC	No	Yes	Would require shredding

Technology	Baseline	Potential baseline	Comments
Supercompaction	Yes		Use 'car crusher' for large pipe
Drummed waste (intact drums) Sorting	Yes		Use for intact drums
Supercompaction	Yes		Supercompact combustibles and other solids not contaminated with organics
Solidification	Yes		Noncombustible liquids
Thermal desorber system for VOC/SVOC	Yes		For solids contaminated with organics, and combustible liquids (off-gas incinerator)
Mobile incineration	No	No	Waste composition too varied
WASTE CONTAINERS/TRANSPORTATION <u>Containers</u> Steel boxes w/reusable overpack	Yes		Size/type to be determined in detailed design
Steel caissons	No	No	Caissons will not be used for waste packaging
Pipe racks w/plastic covers	Yes		Use for large-diameter pipe
Plant bales w/plastic covers	No	No	Not separating plants from soil in 200 Area; soil washing eliminated
Drum overpacks	Yes		Intact drums, as needed
Rail hopper cars	No	No	Too difficult to decon, especially undercarriage
<u>Local Transport</u> Dump trucks	Yes		

Technology	Baseline	Potential baseline	Comments
Belt conveyors (soils)	Yes		
Slurry pipelines (soils)	No	No	Soil washing eliminated; no need for slurry lines
Barges (river pipelines)	Yes		
Gantry cranes, bridge cranes, forklifts, pneumatic pickers	Yes		
<u>200 Area Transport</u> Rail hopper cars (bulk soils)	No	No	Too difficult to decon; especially undercarriage
Rail flat cars (containers/pipe racks)	Yes		
SITE RESTORATION Full reclamation	No	No	Not cost effective due to large volumes of soil removed
Recontouring	Yes		
Revegetation	Yes		
WASTE SITE REMEDIATION: 200 AREA SITES (Except for Surface Soils) <u>In-situ Stabilization</u> Dynamic compaction	Yes		Development testing needed: show dynamic compaction followed by grouting results in minimal settling
Vibration-aided injection grouting	Yes		Same as dynamic compaction
<u>Surface Contaminated Soils</u> Waste removal, processing, and disposal	Yes		Same as 100/300 area baseline technologies

Technology	Baseline	Potential baseline	Comments
WASTE DISPOSAL: 200 AREA <u>Bulk Waste Unloading</u> Bridge cranes	Yes		
Rail car inverters	No	No	Rail hopper cars eliminated
Containment building	Yes		Movable metal building with a fabric liner (See 200 Area macroengineering study report
<u>Packaged Waste Unloading</u> Cranes, forklifts, trucks	Yes		
<u>Bulk Waste Disposal Facility: Low Activity Bulk Wastes</u> Trench	Yes		100-B/C: Trench is single-lined Site-wide: Trench is unlined
Containment building	Yes		See bulk waste unloading facility above
<u>Packaged Waste Disposal Facility: Low Activity Packaged Wastes</u> Open trench (without containment building)	Yes		100-B/C: Trench is single-lined Site-wide: Trench is unlined
<u>High Activity Waste Disposal Facility</u> Reinforced concrete vaults	Yes		Includes movable shielded metal containment building (See 200 Area macroengineering study report)
Slurry dewatering ponds	No	No	Slurry lines eliminated
<u>Site Stabilization</u> Dynamic compaction	Yes		
Vibration aided grouting	Yes		
In-situ vitrification (compactable waste only)	No	Yes	Not proven technology; needs development

Technology	Baseline	Potential baseline	Comments
Concrete 'honeycomb structures' to stabilize compactable waste	Yes		Use prefabricated concrete members placed over waste forms to prevent subsidence
Incinerator/melter (ex-situ vitrification for compactable waste)	No	Yes	Not proven technology; needs development
Sand backfill	Yes		
ISOLATION BARRIERS Hanford barrier	No	Yes	Planned for the 200 Area disposal facility and high activity sites as required. Needs engineering development
RCRA cap	Yes		Not designed for radioactivity. Following performance testing may be replaced by the Hanford barrier for some sites.
LONG-TERM MONITORING Motion detectors, sensors, television	No	No	Not needed for basic monitoring
Subsidence monitoring (lasers)	Yes		
Well sampling/monitoring	Yes		
ACUTE/ISOLATED GROUNDWATER REMEDIATION Site Investigation	Yes		See Scenario 2, Aquifer Remediation
Groundwater Extraction	Yes		See Scenario 2, Aquifer Remediation

Technology	Baseline	Potential baseline	Comments
Groundwater Treatment	Yes		See Scenario 2, Aquifer Remediation
Groundwater Injection	Yes		See Scenario 2, Aquifer Remediation
AQUIFER REMEDIATION Monitoring (in perpetuity)	Yes		Meets remedial objectives; need cost/benefit analysis to justify additional remediation
Institutional controls (in perpetuity)	Yes		
Source removal	Yes		
SCENARIO 1 Monitoring (all groundwater in perpetuity)	No	No	
Institutional controls (all groundwater in perpetuity)			
Site Investigation Pump testing			
Injection testing			
Sampling/analysis			
Groundwater Extraction Wells (100/300/600)			
None (200)			
Groundwater Treatment None			
Groundwater Injection Wells - centralized location			

Technology	Baseline	Potential baseline	Comments
Waste Transport Double-pipe in lined trenches			
Leak detection sumps			
SCENARIO 2 Monitoring (all groundwater during remediation only, 200 Area in perpetuity)	No	No	
Institutional controls (same as monitoring)			
Site Investigation Pump testing			
Injection testing			
Sampling/analysis			
Lithology sampling			
Geophysical surveys			
Groundwater Extraction Wells (100/300/600/200)			
Groundwater Treatment Clarifier/sand filter			
Reverse osmosis			
Selection liquid membrane			
Ion exchange			
Iron coagulation			
Evaporation			

Technology	Baseline	Potential baseline	Comments
Biological denitrification			
Enhanced oxidation			
<u>Groundwater Injection</u> Tritiated treated water - centralized location			
<u>Clean Water Diversion</u> Deep slurry cutoff walls			
Horizontal wells			
Pumping/energy recovery/river discharge			
<u>Waste Transport</u> Double-pipe in lined trenches (untreated, treated/tritiated water)			
Buried single wall pipe (treated nontritiated water, clean water)			
Leak detection sumps			
SCENARIO 3 Monitoring (all groundwater during remediation, 200 Area in perpetuity)	No	No	
Institutional controls (same as monitoring)			
<u>Site Investigation</u> Pump testing			
Sampling/analysis			

Technology	Baseline	Potential baseline	Comments
Lithology sampling			
Geophysical surveys			
Groundwater Extraction Wells (100/300/600/200)			
Lixivant enhanced dissolution contaminant specific lixiviants			
Injection wells			
Aquifer mining Shovel/truck (overburden)			
Suction dredges			
Slurry transport			
Groundwater Treatment Clarifier/sand filter			
Reverse osmosis			
Selective liquid membrane			
Ion exchange			
Iron coagulation			
Evaporation			
Biological denitrification			
Enhanced oxidation			
Sediment washing wet screening			
Vacuum filter dewatering			

Technology	Baseline	Potential baseline	Comments
Tritium separation (heavy water plant)			
<u>Groundwater Disposal</u> Columbia river discharge			
<u>Clean Water Diversion</u> Deep slurry cutoff walls Hydraulic excavating Machine			
Wide trench			
Horizontal wells			
Pumping/energy recovery/river discharge			
<u>Waste Transport</u> Double-pipe lined trenches (untreated, treated/tritiated water)			
Buried single wall pipe (treated nontritiated water, clean water)			
Leak detection sumps			
Bulk rail hopper cars (for mined sediment fines)			

N/A = not applicable

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APPENDIX B

VOLATILE ORGANIC COMPOUND-ARID INTEGRATED DEMONSTRATION

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CONTENTS

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1.0 INTRODUCTION

The VOC-Arid ID Site at the Hanford Site is one of many demonstrations at DOE sites being conducted through the U.S. DOE Office of Technology Development. Field activities are being coordinated by PNL and the WHC Environmental Division. The demonstration is being conducted in coordination with the carbon tetrachloride ERA.

Technology demonstrations include emerging technologies that can be used to characterize, remediate, and monitor carbon tetrachloride and co-contaminants. The overall goal is to improve the performance and decrease the costs of carbon tetrachloride remediation while maintaining a safe working environment.

2.0 SITE CHARACTERIZATION TASKS

Standard site characterization tasks to be conducted as part of the ERA to decrease characterization time and costs include: 1) sonic drilling, 2) cone penetrometer testing, 3) SEAMIST, and 4) certain analytical technologies.

2.1 SONIC DRILLING

The effectiveness of sonic drilling has been demonstrated at the Hanford Site. Additional testing around the carbon tetrachloride disposal sites is currently underway and will focus on developing, testing, and evaluating the technology for deeper depths and larger diameter well completions; and assessing the impact on samples collected during drilling.

2.2 CONE PENETROMETER TESTING

Another technology system that could augment and in some cases replace standard drilling at the Hanford Site is cone-penetrometer testing (CPT). The CPT is an instrumented rod that is hydraulically inserted into the soil. The CPT has been used extensively for soil studies and more recently in environmental investigations.

In September 1991, Applied Research Associates conducted tests in the 200 West Area to evaluate the feasibility of using existing CPT in Hanford Site soils. The maximum depth reached in tests conducted at the Hanford Site was 20 m. Six tests showed successful application to a depth of 3 m or more. In addition, soil-gas sampling using the CPT was successfully conducted during selected tests.

Application of the CPT technology will require the development of an improved ability to penetrate the coarse gravel units common to 200 West Area soils. Additional development of the CPT is being pursued with the Applied Reasearch Associates as part of the integrated demonstration.

2.3 SEAMIST SYSTEM

The Science and Engineering Associates, Inc., Membrane Instrumentation and Sampling Technique (SEAMIST) system is designed to collect in-situ depth discrete soil-gas samples and air permeability data during drilling. The SEAMIST is currently being tested in a 200 West Area borehole principally to evaluate its ability to be deployed in wells/boreholes with varying configurations and soil types, extract depth-discrete soil samples, maintain sample representativeness, and measure air permeability during drilling. If successful, the SEAMIST will be investigated for use with other sensors.

2.4 ANALYTICAL TECHNOLOGIES

Two analytical technologies being developed for use in 1993 and 1994 are supercritical fluid extraction, and an unsaturated flow apparatus. Supercritical fluid instrumentation is commercially available and may be used to analyze for nonvolatile and semivolatile organic co-contaminants. The Unsaturated Flow Apparatus, developed by Washington State University) may be used to better predict the migration of VOC and water in the subsurface environment of arid sites by achieving steady state unsaturated flow conditions in soils through the use of centrifugal force and precision fluid flow. Initially, tests show that data acquisition requires significantly less time using the Unsaturated Flow Apparatus as compared to other technologies.

3.0 WELL-FIELD DEVELOPMENT

The current well-field design incorporates extraction wells for removing soil vapor from the subsurface and monitoring wells to provide indication of the radial influence of the extraction wells. The extraction and monitoring wells are selected from existing steel-cased vertical wells and perforated at intervals based on an assessment of the geology, distribution of radioactive contaminants in the soil, accessibility, and well construction. Presently, it is preferable to use the existing wells due to the costs, duration, and safety issues related to drilling through radiologically-contaminated soils.

Several innovative technologies are being investigated in coordination with the ERA to enhance the removal of the carbon tetrachloride in the well field. These technologies include the use of in-situ heating; directional drilling for potential use in injection/extraction; and well field monitoring devices.

3.1 IN-SITU HEATING

Soil heating tests will be conducted during the spring of 1992 at an uncontaminated outdoor site, and data from a bench-scale laboratory test will help determine the ability to remove TCE and perchloroethylene from clays by combined soil heating and soil venting. These activities will culminate in detailed specifications for a full-scale power system for testing at the VOC Non-Arid ID.

3.2 DIRECTIONAL DRILLING

The VOC-Arid ID, in conjunction with the ERA and other DOE integrated demonstrations, is conducting development and demonstration activities to test and evaluate directional drilling techniques for applications at the Hanford Site and other Arid sites. Directional drilling techniques have been demonstrated at the DOE's Savannah River Site, Sandia National Laboratory, and at Tinker Air Force Base for shallow environmental applications. However, additional development and demonstrations are needed at the Hanford Site because the geology of the site is much different than others where testing has been conducted, drilling fluids must be contained and minimized, and depths of 80 to 250 ft are required to address the primary contamination zones.

3.3 SENSORS

Sensors for subsurface VOC monitoring are needed to support operations of the vapor extraction system (VES) and improve the efficiency of the cleanup. Improved sensor systems for carbon tetrachloride and other VOC are being developed to meet these needs and also to support development and demonstration of enhanced remediation systems.

Sensors currently under development for both off-gas and borehole monitoring of VOC include a solvatochromatic fiber-optic (Optrode) sensor from Lawrence Livermore National Laboratory, portable acoustic-wave sensor (PAWS) from Sandia National Laboratory, and total organic chloride (TOCl) optical emissions sensor from PNL.

The PAWS and Optrode will also be integrated with borehole delivery systems for real-time monitoring of subsurface VOC concentrations at discrete depths. These sensors will be integrated with characterization technologies such as SEAMIST and CPT to provide enhanced subsurface characterization and monitoring capability.

4.0 TREATMENT TECHNOLOGY DEMONSTRATIONS

Several innovative technologies are being investigated in coordination with the ERA to improve the treatment process of the carbon tetrachloride, either aboveground or in situ. As the existing treatment process is costly and requires the offsite regeneration of the granular activated carbon, it is the goal of the ERA to find a technology, or combination of technologies, which will treat the carbon tetrachloride at the site at less expense and still meet regulatory requirements.

4.1 OFF-GAS TREATMENT

Off-gas VOC treatment technologies currently being readied for demonstration include a steam reforming system (Synthetica Technologies, Inc.) for GAC regeneration and a membrane separation system (Membrane Technology & Research, Inc.) for concentrating VOC in a liquid form for subsequent recycling or treatment. The Synthetica Detoxifier is a non-catalytic, resistively heated steam reforming process for destruction of toxic organic compounds. The steam reforming system will be demonstrated in the spring of 1992 using GAC loaded with carbon tetrachloride and chloroform from the ERA VES. Synthetica and Sandia National Laboratory will conduct the demonstration. If successful, the steam reforming system will be considered for longer-term testing and use to support the ERA.

A pilot-scale membrane separation system will also be demonstrated this year to evaluate its effectiveness for reducing VOC loading of GAC, thereby reducing the ultimate cost of GAC regeneration. Membrane Technology and Research, Inc., will be demonstrating the pilot-scale commercial system in collaboration with WHC. Performance analysis and cost analysis will be conducted as part of the demonstration to fully evaluate the benefits of the membrane separation process for enhancing the existing VES system.

Technologies are also being developed to destroy the VOC to minimize the need for GAC and eliminate the need for liquid-phase VOC treatment. These technologies include high-energy electrical discharge (corona) technology being developed at PNL, and a Tunable Hybrid Plasma system being developed at Massachusetts Institute of Technology. The corona technology is currently being tested with TCE at the bench-scale for demonstration at the VOC Non-Arid ID, and will be tested and scaled-up for demonstration with carbon tetrachloride at the Hanford Site. The Tunable Hybrid Plasma will be tested at a bench-scale during FY92. Both systems are scheduled for larger-scale demonstrations in 1993.

4.2 IN-SITU CONTAMINANT DESTRUCTION

In addition to heating, research efforts are underway to evaluate the feasibility of producing a high energy corona in situ to destroy VOC in place. Laboratory tests will be conducted to investigate the electrical characteristics of High-Energy Corona in soils, and a bench-scale test will study the ability to remove carbon tetrachloride from a silty soil in support of the ERA and VOC-Arid ID.

4.3 SENSORS

Several parameters are measured at selected locations on the existing VES processing equipment for operational, engineering, compliance, and safety purposes. Particulate radiation is measured by alarmed continuous air monitors between the high-efficiency particulate air filter banks as a backup safety feature. Vapor carbon tetrachloride concentration measurements are made before, between, and after the GAC canisters for compliance monitoring and system trend analysis with in-line sensors. In-line ports to allow soil vapor samples to be drawn for field gas chromatograph analysis or laboratory analysis are also available. In addition, naturally-occurring radon measurements are made before, between, and after the GAC canisters. Further development of these detectors is required as part of the Arid ID. The initial focus is to demonstrate real-time process monitoring for the soil vapor extraction off-gas system to provide direct support to the ERA. These sensors are discussed in the well-field development technology needs and demonstrations section.

4.4 GROUNDWATER TREATMENT

Although not part of the ERA, treatment of the 7 mi^2 carbon tetrachloride plume underlying the disposal sites may need to be addressed in the future. The difficulty in remediating the groundwater is related to cost and uncertainties in using existing pump-and-treat technologies, and the combination of carbon tetrachloride, with other chemical and radiological contaminants in the groundwater.

An in-situ bioremediation process is being developed by PNL that uses native micro-organisms to anaerobically destroy carbon tetrachloride and nitrates in groundwater. A field test to demonstrate and evaluate the effectiveness of in-situ bioremediation of carbon tetrachloride in groundwater is scheduled to be conducted in the 200 West Area north of the ERA site. Field test site development will continue through 1992 and 1993, with initial tests of microbial stimulation scheduled for 1994.

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APPENDIX C

ASSESSMENT OF POTENTIAL BASELINE TECHNOLOGIES

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Table C.1. Assessment Scores for Potential Baseline Technologies.

Technology/Application	Screening Score [1]	Major Criteria contributing to Screening Score
In Situ Groundwater Treatment	250	Potential Cost Savings, and Potential Long Term Effectiveness and Risk Minimization
Automated/Remote Control Equipment	225	Potential Worker and Public Safety
In Situ Vitrification to Minimize Subsidence of Compactible Waste placed in a burial ground	200[2]	Potential Long Term Effectiveness to improve public safety
Physical Separation/Soil Washing	200	Potential for Waste Minimization
Hanford Isolation Barrier	175	Potential for long term effectiveness and risk minimization
In Situ Vitrification of Cribs and Burial Grounds	175	Potential for long term effectiveness and risk minimization
Chemical Agents to Enhance Dust Control	175	Similar scores for many of the criteria.
Ex-Situ Processing of Compactible Waste (ex-situ vitrification or incineration/melting)	150[2]	Potential for long term effectiveness and risk minimization

1. To the nearest 25. An existing baseline technology scores 50.

2. Requires an engineering study to better compare the technology with baseline technologies.

Table C.2. Example Scoring Matrix for Physical Separation/Soil Washing. All scores are based on comparison with baseline technologies.

Criteria	Score	Weight	Weighted Score[1]	Comment
Worker and Public Safety	0	18.0	0.0	No improvement
Long Term Effectiveness and Risk Minimization	0	12.7	0.0	No improvement
Environmental Impact	5	9.9	49.5	Less impact to the environment than the baseline, because much of the soil moved will be replaced.
Waste Minimization	10	8.4	84.0	90% Volume reduction projected
Probability of Success	8	4.6	36.8	Previously applied offsite
Cost Savings	3.5	4.1	14.4	Lower cost of disposal vs. treatment cost
Faster Remediation	2	3.1	6.2	Faster than baseline since less material will need to be shipped and disposed, and quicker site restoration.
		Total Weighted Score	191	

1. Weighted Score = Score X Weight

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Purpose

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